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TABLE OF CONTENTS:

ENGINEERING NEWS OF THE WEEK..... 185
A Photograph of the Late President McKinley, Taken on Sept. 6 (illustrated)..... 186
The Improvement of the Lower Mississippi River.. 186
The Work of the Engineer..... 187
Repairing a Leaking Coffer-Dam and Pile-Driving Methods at the Leech Lake Storage Reservoir, Minnesota (illustrated)..... 187
Results from the Use of Highly Superheated Steam in Engines..... 189
A Clay-Tile Fireproof Floor Construction for Long Spans (illustrated)..... 190
Rating and Testing of Electrical Machinery..... 190
Coal Tipple and Cantilever Bridge Over Tygart's Valley River, near Fairmont, W. Va. (illustrated). 192
The Management of Septic Tanks and Bacterial Contact Beds..... 193
Book Reviews..... 198
A Novel Electric Cable Railway at Palermo, Sicily (illustrated)..... 199
Texas Petroleum..... 199
A Regenerative Accumulator and its Application for Using Exhaust Steam (illustrated)..... 200
A New Trench Excavating Machine (illustrated)... 200
Agricultural Machinery in the Canadian Pavilion at the Glasgow Exhibition (illustrated)..... 201
Standards of Measurement in Field Engineering... 203
Experiments on the Escape of Steam Through Orifices (illustrated)..... 204
The Butler Steam Shovel Cableway at the Missionfield Coal Mine, Illinois (illustrated)..... 205
Some Lessons from the Macadam Pavements of Albion, N. Y. (illustrated)..... 205
Workshop Methods..... 207
Thirty-Ton Folding Gantry Crane for the Chesapeake & Ohio Ry. Wharves, Newport News, Va. (illustrated)..... 208
EDITORIAL NOTES..... 196
Thoughts Suggested by the National Bereavement—The International Engineering Congress at Glasgow—Newspaper Reports of Technical Matters—A Record of Experience with the Latest Methods of Sewage Treatment—A River and Harbor Convention at Baltimore—National Appropriations to Aid Commercial Rivals—How Deep Should American Harbor Entrances be Made?—Maintaining Macadam Roads at Small Expense.
EDITORIAL:
Engineers and Patents..... 197
LETTERS TO THE EDITOR..... 197
How Not to Thaw Dynamite—A Concrete Chimney at Bellinzona, Switzerland (illustrated)—Notes and Queries.

BIDS FOR A SEWERAGE SYSTEM AT SANTIAGO DE Cuba will be opened on Oct. 21, 1901, at Headquarters of the District of Santiago, Office of the Engineer Officer. The work will include about 52,000 ft. of vitrified pipe sewer, 1,730 ft. of 33-in. double ring brick sewer and about 2,400 ft. of 24 and 42-in. force main, besides Y-branches, 80 single and 15 double flush tanks, some 36,000 ft. of 4 and 6-in. house connections and various accessories. There is also a pumping station to be built. The department has on hand and will supply all the cast-iron pipe for the force main and 11,000 ft. of 15 to 4-in. vitrified pipe. Plans may be seen and specifications obtained at this office or at the Engineer Office, Santiago, Cuba.

A POTABLE WATER SUPPLY for the City of Mexico is to be developed by a syndicate of New York capitalists, which has bought what is known as the Mackensie concession. The water will be taken from springs at Alamoloya. It will be pumped in three stages to an elevation of 1,456 ft., and then will fall 1,214 ft. to the city. The total length of pipe line and canals will be about 84 miles. Power for pumping will be developed from three high water falls on the Matinaltenongo River, 24 miles from the springs, and transmitted electrically. The fall of the water supply from the crest of the ridge to the city will be used to develop power for transmission to the city. Mr. Warren H. Loss is contractor for the work. Mr. George M. Brill is chief and Mr. Ernest Abs Hagen is consulting engineer to the syndicate.

MUNICIPAL OWNERSHIP OF WATER-WORKS at Los Angeles, Cal., seems assured after a long agitation in favor of that step and much litigation. By a vote of 6,284 to 1,267 the people, a few days ago, authorized the issue of $2,000,000 in bonds for the purchase of the existing private works. This practically ratifies a compromise agreement made in July between the city council and the water company. It is expected that the bonds will be put on the market at once and that the transfer of the works to the city will be made before the close of the year.

AN ORDINANCE FOR THE PREVENTION OF ELECtrolysis has been submitted to the city council of Norfolk, Va., by a joint committee of the two branches of the city council and the board of electrical control. It provides that on or before Feb. 1, 1902, all companies using electrical current shall

provide and put in use the latest designs and most effective appliances to control and effectively retain such currents in their proper channels, and on their own wires, tracks and other works so as to prevent injury to pipes and other structures, belonging to the city of Norfolk, in the streets and alleys or other parts of said city, and repair and renew said mains and appliances, or from time to time change and improve the same as may be necessary to accomplish said purposes, all at its or their charges and expense, and at its or their own risk, selecting and adopting such means and appliances as shall prevent injury to pipes and other structures belonging to said city as aforesaid.

The ordinance also contains a provision for the payment by the street railway company for all damages to water mains heretofore caused by electrolysis, the same to be determined by an electrical survey, supplemented, if necessary, by arbitration. Mr. W. T. Brooke is city engineer of Norfolk and a member of the board of electrical control.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the result of a collision with a road engine on a crossing of the Northern Pacific Railway, near Jamestown, N. D., on Sept. 8. Five men were killed and six others seriously injured. One of the most serious railway accidents of the week in its possibilities occurred to the Chicago Limited Express, west bound on the West Shore Railway, at 2.30 a. m., Sept. 12. This train ran into an open switch at Eastwood, three miles east of Syracuse, and 50 persons were injured, though none of them seriously. The train was running at the rate of 45 miles per hour, every car was crowded; and as a result of the accident the engine, two coaches and three express cars were overturned, the sleepers, forming the remainder of the train, remained on the tracks.

THE BOILER EXPLOSION on the Delaware River steamer "City of Trenton" on Aug. 28, by which 26 persons lost their lives was investigated at a hearing before the U. S. Supervising Inspectors on Sept. 9. Those of the engine-room force remaining alive testified that there was plenty of water in the boiler just previous to the explosion. The chief engineer testified that he examined the forward fireroom glass within five minutes of the explosion and found from 1 to 1½ gages of water in it, which would indicate a depth of 3 to 5 ins. over the crown-sheet of the furnace. An oiler testified to a similar depth in the glass only two minutes before the explosion occurred. The pressure carried at the time of the explosion was said to be 160 lbs. The coroner's investigation is to be held on Sept. 24 and a special jury of experts has been formed. Among its members are Messrs. S. M. Vauclain, of the Baldwin Locomotive Works; J. S. L. Wharton, of the Harrison Safety Boiler Works; Henry J. Hartley, Superintendent of the boiler shop of the Cramp Ship & Engine Building Co., and a number of other well-known Philadelphia engineers.

STEAM BOILERS UNDER SIDEWALKS in Chicago, Ill., are forbidden and must be removed, under recent orders from Mayor Harrison. It is not yet known how many boilers are thus located in the city, but Boiler Inspector Blaney is already issuing orders for removal.

THE REPORT ON THE OLD BROOKLYN BRIDGE, ordered by District Attorney Philbin, has been received, but is not made public in full. Mr. Philbin appointed Messrs. E. Duryea and Joseph Meyer, Members Am. Soc. C. E., to make a careful examination of the structure and especially to report upon the cause of the breaking of some of the truss suspenders on July 24 last. From the part of the report published we quote as follows: "We believe the present margin of safety to be so small that the necessity for repairs is very urgent, and have suggested means by which the safety can be increased without materially interfering with traffic, at a comparatively small cost." This report will be submitted to other eminent engineers, says Mr. Philbin, and their advice obtained before further proceedings are taken. As this journal has before stated, the suspenders which made the trouble last July can be readily changed so as to avoid any further rupture—and at comparatively slight expense. In the report, so far as given out, we find no note of alarm as to the cables or main structure; and in the interval of a quarter of a century that has elapsed since this first great suspension bridge was built, engineers have devised and used better means of suspending the trusses to the cables; and these later devices can now be substituted for the failing suspenders on the Brooklyn bridge.

A COMPRESSED-AIR LOCOMOTIVE has been built at the Rome Locomotive Works, at Rome, N. Y., for trial on the Brooklyn Rapid Transit Railway between Fulton Ferry and Navy St. It weighs over 25 tons, and is said to have cost $35,000.

OIL-BURNING LOCOMOTIVES are being introduced on the Southern Pacific, but are causing some complaint on suburban lines because of the noise made by the oil burner and the odor when the train is stopped at a station. It is thought this can be overcome by more careful handling of the valves controlling the oil supply.

PRESSED STEEL CARS are being turned out from the works of the Pressed Steel Car Co. at the rate of over 100 per day. During the week ending Sept. 13, the company informs us that it shipped 628 cars, an average of 105 cars per day. Besides these completed cars, large shipments of truck frames, bolsters and other car parts of pressed steel were made independently. The consumption of steel by the company is over 1,600 tons per day and over 500,000 tons per annum. The most remarkable thing in connection with this industry is that it has been built up in only four years, it being only about that time since the first pressed steel cars were built and put in service. Up to Sept. 1, 1901, the company has built 46,030 cars, and has used in their construction 1,657,080,000 lbs. of iron and steel. If these cars were made up in a single train it would be 322 miles in length and would carry over 4,500,000,000 lbs. of freight.

A GRAIN ELEVATOR AT PORT ARTHUR, ONT., is being built for the Canadian Northern Railway, and it will have a storage capacity of about 1,250,000 bushels. This elevator is of semi-fireproof construction, the bins being built of concrete, reinforced by steel bands, in the form of inverted pyramids. The majority of the bins are 14 ft. square by 70 ft. deep. The unloading machinery will handle 250 cars per day and 100,000 bushels per hour can be loaded into vessels. The building is 100 × 250 ft. and 175 ft. high above the water level.

A MACHINERY HALL, at the Armour Institute, Chicago, is to be built with the first expenditure from the $1,000,000 fund recently given to the Institute by the Armour family. It will be used for technical instruction in machine shop and foundry work, and will be equipped accordingly with the most modern machinery.

THE RUSSIAN BATTLESHIP "RETVIZAN," built by the Cramps, in Philadelphia, has had her builders' trial trip off the Delaware Capes. The contract calls for 18 knots for 12 continuous hours. This ship carries a very heavy battery, and all her batteries were fired during this test. The main battery consists of four 12-in., 12 6-in. and 20 3-in. guns, all made in Russia, and 20 47-mm. Hotchkiss rapid-fire guns. The "Retvizan" combines in her plans the results of the lessons taught in the Spanish-American war. The hull is covered amidships with 9-in. armor plate, combined with a heavy protective deck brought down to the edge of the belt plating. The upper battery is covered by 6-in. plate, tapering to 5 ins.

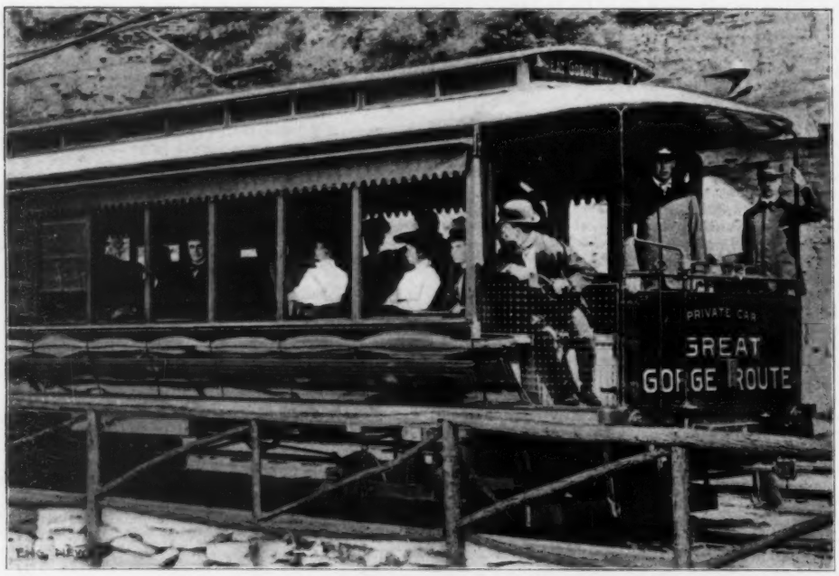
PEARY'S ARCTIC EXPEDITION is heard from by the return of the Peary arctic steamer "Erik" to Cape Breton on Sept. 13. Lieut. Peary reports that he left Fort Conger, lat 81.44° N. on April 15, 1900, with Henson and five Esquimos. He crossed Rebeson's Channel to West Greenland and reached Cape Britannia, 83.24° N., in May. From this point, with Henson and one Esquimo, he reached Lockwood's "farthest North" cairn, 83.24.5° N., on May 8. At 83.39° N. he rounded the northern extremity of Greenland and found the coast rapidly trending eastward. He then turned his course directly north over the sea ice, but only advanced to 83.50° N., when he was stopped by the broken pack and much open water. Returning to the shore again, he went eastward about 160 miles beyond Lockwood's cairn to lat. 83° N., long. 25° W., or about one degree from Independence Bay, discovered by Peary on July 4, 1892. He saw plainly, to the south, the high mountain there visible. Thus, while Lieut. Peary has not reached the Pole, he has defined the northern limit of Greenland, one thousand years after the discovery of its southern extremity by "Erik the Red." He has also reached the highest latitude attained by man in the Western Hemisphere. For the season of 1901 he had determined to try to go north from Cape Hecla, with Fort Conger as a base. Mrs. Peary and her daughter, on the "Windward," spent eight months in Payer Harbor, near Cape Sabine, and they return on the "Windward," soon due at St. Johns, N. F.

FREE CLASSES IN CIVIL, MECHANICAL AND electrical engineering and chemistry were opened last year by the Cooper Union, of New York city, and this fact may be of interest to some of our readers. These schools are under the direction of George W. Plympton, A. M., C. E., and they are provided with completely equipped laboratories sufficient to provide for practical instruction for a three-years' course of study. For the first two years in the engineering courses the laboratory work is the same for each. The chemical laboratory is also sufficiently complete to carry the student through quantitative analysis. For the general programme of exercises for the three years apply to Assistant Secretary L. C. L. Jordan, Cooper Union Free Day Schools, New York city.

AN ALEXANDRIA-SHANGHAI RAILWAY, about 6,400 miles long, is proposed by an English engineer, says U. S. Consul-General R. Guenther, of Frankfort, Germany. Of this line the middle or Indian division, of 2,125 miles, is already built. From Alexandria he proposed to build a line over the Isthmus of Suez to Akaba and thence to Kurveil and Barsorah, through South Persia and across Baluchistan to the existing Indian railway net. From Shanghai to Chunking the road would follow the Yangtze Kiang, then, by way of Shantung, Yunnan and Talifu to Kunlog, the eastern terminus of the Indian railways. No estimates of cost and time accompany this project.

A PHOTOGRAPH OF THE LATE PRESIDENT McKINLEY, TAKEN ON SEPT. 6.

To many of our readers in the cities who have access to the popular illustrated papers and magazines, the accompanying photograph showing the late President McKinley and his party on their excursion through the Niagara Gorge, will be only one out of many such interesting scenes, which the camera and the half-tone process spread abroad in such profusion at this time. But to other readers, located in remote parts of the country, or in foreign lands, this photograph of our late President, taken only a few hours before he was struck down by the assassin's pistol, will, we are sure, be full of interest.



PRESIDENT McKINLEY AND PARTY ON THE NIAGARA GORGE ELECTRIC RAILWAY, FRIDAY MORNING, SEPT. 6.

(From a photograph copyrighted by G. D. Brinckerhoff.)

It will be remembered that on the morning of that fatal Friday, the Presidential party visited Niagara Falls, and were taken by special cars over the Niagara Gorge electric railway. The photograph shows the President's car on its trip up the gorge.

THE IMPROVEMENT OF THE LOWER MISSISSIPPI RIVER.*

By J. A. Ockerson, M. Am. Soc. C. E.†

A stream carrying the drainage of an area of 1,256,000 sq. miles, having 15,000 miles of navigable tributaries, and which is itself 2,500 miles in length, justifies the appellation of "Father of Waters."

The regulation and control of a river of such magnitude involves problems which greatly tax the ingenuity and skill of man to solve. In its lower half, the river oscillates in volume from a minimum flow of 65,000 cu. ft. per second to a maximum of 2,000,000 cu. ft. per second, and the oscillations in stage between extreme high and low water amount to 53 ft. About 1,250 miles above its mouth the Missouri river enters, with its sediment-laden waters that are prolific in hindrances to navigation. This sediment, and that derived from the erosion of the alluvial banks, form the sand bars which develop during the falling stages of the river, and become, at low stages, formidable obstructions to navigation. This erosion takes place, for the most part, on falling stages. The banks being composed of alternate layers of sand and silt, or clay, are disintegrated by the layers of sand being washed out when the water in the saturated banks recedes toward the river as it falls. This leaves the clay unsupported, and causes the banks to collapse in large masses, which slide into the river and then disintegrate from the force of the current. In the 885 miles of the river lying below the mouth of the Ohio River, this erosion or caving amounts to an average of 9½ acres in area for each mile of river in a year, or a volume of about 1,003,579 cu. yds. for each mile of river per year. The total annual amount of erosion for this reach equals 10 sq. miles, 86 ft. in depth.

In its natural condition the river below the mouth of the Ohio overflowed its banks at flood stages, which generally occur in the spring months. The destructive floods invariably come from the Ohio River and its tributaries, chief among which are the Tennessee and Cumberland rivers, which drain a region in which the rainfall is exceptionally heavy. The alluvial basin subject to overflow covers an area of about 30,000 sq. miles. It has a soil of remarkable fertility.

From St. Louis to Cairo, a distance of 180 miles, the work projected at present contemplates a channel 8 ft. deep at low water, and having a width of 2,000 ft. The overflow stages are not of such frequent occurrences as to justify expensive embankments or levees to control the floods. The high stages occur in the months of May and June; while the low-water season generally begins with September and often extends into the winter months. The system of improvement adopted for this reach consists in contracting the channel and closing side chutes or channels by means of permeable dikes and hurdles. This requires that the banks must be held, which is done by means of revetment. Work is also done with hydraulic dredgers and temporary portable dikes, which are used to open channels through obstructing bars. On the completion of the contraction works now in progress, it is expected that a navigable channel of 8 ft. in depth of low water will be readily maintained.

The Mississippi River Commission is charged with the survey and study of the physical conditions of the river from its source to the Gulf of Mexico.

The chief construction work of the Commission has been confined to that portion of the Mississippi River lying between the mouth of the Ohio and New Orleans. The work has consisted of contracting the channel in wide places, revetment, and dredging. The present law contemplates a channel not less than 9 ft. in depth at the lowest stages of the river. Under natural conditions this depth prevails for an average period of about 8 months in the year. The low-water period generally ranges from the middle of August to December. This is, however, the period when the grain crops are moving and good navigation is most urgently needed. As the improvement of a stream of such great length will necessarily require a long period of time, temporary expedients for the relief of navigation must be used, for which purpose hydraulic dredgers of large capacity have been constructed. An experimental dredger was first constructed and worked for a period of over two years, for the purpose of ascertaining whether dredging in a stream where such enormous quantities of material are continually moved along the bed by the current, could give any beneficial results, and also to learn by experience how to manœuver and operate a dredger and discharge the material in strong currents. These experiments and work done since then, have fully established the fact that a powerful hydraulic dredger can open an ample navigable channel through an obstructing sand bar and maintain it at a cost fully justifying the expense. For the next low-water season there will be in the service of the commission a working fleet of nine dredgers, with a combined working capacity of over 10,000 cu. yds. per hour.

When in operation, the dredger is manipulated by two wire cables, 1 in. in diameter and 1,200 ft. long, one end being attached to hauling drums 48 ins. in diameter, and the other to hollow iron piling securely placed in the bed of the river. With the cables all paid out, the dredger is at the lower side of the sand bar to be cut through, and it is pulled up-stream at a speed varying with the depth of the cut and character of material. For depths of 5 ft., the rate of movement ranges from about 100 to 150 ft. per hour, or sometimes even as high as 200 ft. of cut per hour. After one cut is finished, the hauling cables are shifted; the dredger is again dropped back to the lower edge of the bar; and another cut is made along the side of the first cut. This process is repeated until sufficient width has been obtained. After the first cut has been opened, the current is an active agent in assisting the development of a channel, provided the cut has been properly located with reference to the natural direction of flow. Otherwise, the artificial cut may be filled as fast as it is opened, by the material which is moved along by the current.

Where the dredged cuts are properly located, a satisfactory channel can be readily opened; and experience shows that when once opened, the channel will maintain itself until there is a considerable fluctuation in stage, such as to change the direction of flow of the thread of the current. Such a dredger is operated at a total cost of about $100 per day of 24 hours.

REVETMENT AND CONTRACTION WORKS.

In a stream flowing through a bed of its own formation, the banks are naturally very easily eroded; and a lateral movement in one direction or the other is continually in progress. Any permanent improvement of navigation requires the banks to be made stable, to prevent the flanking of the channel works, and to stop the contribution of eroded material which builds up the obstructing bars. Active bank erosion is confined to the concave sides of the bends in the river, where the thalweg lies close to the bank. These banks are sometimes 50 ft. in height above low water, and extend down below for an equal depth. This gives a steep bank about a hundred feet high, which must be protected in such a way as to prevent its erosion and disintegration, a very difficult and expensive work. There is no rock near at hand for use as ballast or paving, and it has to be brought from quarries several hundred miles away. The willows used for covering the bank below the low-water line, grow in profusion along the battures; but even the supply of willows would be severely taxed to meet the demands of a general system of bank revetment. The method now in vogue for holding the banks, consists of a covering of fascine-willow mats ballasted with stone and usually 300 ft. in width, extending from the low-water line out into the stream. These mats are built and sunk in lengths of about 1,000 ft. The only limit to the length is that fixed by the strength of the head-lines which hold the floating mat in place during construction. With a strong current, and large accumulations of drift, it is often difficult to hold a very long mat.

The form of mat described is found to serve the purpose very well, the weakest point being the wire fastenings, which, in the course of time, corrode and break. When once in place, the ballasted mat filled with sediment will remain, under ordinary conditions, even without fastenings. To obviate the defects incident to corrosion, experiments are being made with silicon bronze and other wires, and different wire coatings.

The following materials are used per 100 sq. ft. of mat: Willow brush, 1.639 cords; poles, 0.053 cord; steel wire, 4.861 lbs.; silicon bronze, etc., wire, 0.546 lb.; wire strand, 10.965 lbs.; clamps or staples, 1.500; and stone, 0.625 ton. Another form of mat, called a crib mat, is used with good results where the plant is limited, and it also has the advantage of eliminating the use of wire and wire strand. These mats are constructed on temporary ways built on the bank near where the willows are cut. The dimensions are usually 100 ft. × 150 ft., and about 1 ft. thick; but the mat may be of any suitable size or thickness. Each mat as completed is launched into the river; and when a sufficient number have been constructed, they are bound together and towed by a tug or tow-boat to the point required. They can be bound together to form a long mat, or they can be sunk separately. The mat costs 3 cts. per sq. ft. afloat, and 6 cts. in place, and requires 12 lbs. of stone per sq. ft. to sink it.

After the subaqueous portion of the bank has been securely protected, the upper part of the bank is graded to a slope of 3 to 1 by a hydraulic grader, and the graded surface is paved with stone to a thickness of about 10 ins. This paving is carried up to within 10 ft. of the top of the bank, and sometimes is carried right up. Where the ballast stone is very far from the work, artificial stone of cement and river gravel, which is usually near at hand in abundance, is made use of. German Portland cement is used in the proportion of 1 cement to 13 of sand and gravel. The mixer and its machinery is carried on a tramway laid on the gravel bar where the material is abundant, and a series of molds are placed on the ground along the tram. The blocks are made 7 ins. thick, 12 ins. deep, and 6 ft. long, and after hardening are broken into sizes to suit. This artificial stone weighs about 140 lbs. per cu. ft. A small plant will make about 160 tons per

*Extracts from a paper read before the International Engineering Congress at Glasgow.

†Member of the Mississippi River Commission, St. Louis, Mo.

lay, at a cost of about $1.40 per cu. yd., as against $2 or more for the stone in some localities.

Experiments are being made with upper bank paving of concrete 4 ins. thick laid in situ. Brick is also being tried for ballast and paving.

The average cost of a complete bank revetment, with a subaqueous mat 300 ft. wide and upper bank graded and paved, is $27 per running foot of bank.

In some cases spur dikes or buttresses, spaced 450 ft. apart, have been used to hold high banks and check the erosion, constructed of willows and stone built up in layers on a broad foundation mat. In some places these have failed by scour taking place behind them, as the above water bank is left unprotected. Such spurs properly spaced would doubtless be successful, and perhaps more economical than the standard continuous revetment. The closure of chutes or side channels is effected by means of brush and stone dams and pile dikes, built to a height somewhat above low water.

LEVEES.

The alluvial basins below the mouth of the Ohio, which are subject to overflow, cover an area of about 30,000 sq. miles, or about equal to the area of Scotland. At high stages, these lands, under natural conditions, are flooded to depths varying from a few inches to 15 ft., or even more. Originally they were densely wooded; but the extraordinary fertility of the soil attracted the agriculturist, who settled there and cleared up the lands at the risk of being overwhelmed by the floods. Under such conditions, only the very highest of the lands, which always lie near the river banks, could be utilized; and most of the land was left in its wild state until the inhabitants undertook to build barriers to keep out the annual floods. In this way the levee system began; and so long as it was confined to isolated districts, leaving the major portion of the basins still open to the floods, the levees required were of small dimensions.

When the improvement of the river began, it soon became apparent that it was important to confine the waters, as far as practicable, to the same general channel lines at both low and high stages. This meant that the floods must be confined throughout the whole length of the alluvial valley. To restrain all the enormous volume of water necessarily required much higher and stronger levees than had been found sufficient to protect isolated patches of land. As was expected, the river in flood, confined between levees a mile or two apart, reached a plane considerably higher than when it was allowed to spread unimpeded over the wide expanse of basins. While the cause seemed quite apparent, many people attributed the rise in the flood plane between the levees to a filling up of the bed of the stream. This led to an extended investigation by the author, extending over several hundred miles of river, the conclusion arrived at being that there had been no very decided change in the bed; but, on the whole, the evidence pointed to a lowering of the bed. This view was further substantiated by the fact that the low-water plane was very materially lower than it was prior to the completion of the levee system, although the depth and volume was equal to those of former years.

Prior to 1882 the construction of levees was confined to the several states and to private landowners. In that year there occurred one of the greatest floods known, and it became apparent that the aid of the general government was essential to adequate protection. Appropriations of funds were made; and since that time the government has spent about $16,000,000 in levee construction, while the several states have spent about double that sum. The total length of levee lines below the mouth of the Ohio is about 1,450 miles; but they still lack much to bring them up to the dimensions and height deemed necessary for safety.

The ordinary standard levee is built with a crown of 8 ft., and side slopes of 3 to 1. The crown and sides are sodded with a very tenacious grass, known as Bermuda grass. Where the levee exceeds a height of 11 ft. it is reinforced on the land side with a banquette of earth, which reaches a height of 8 ft. below the top of the levee. The crown of the banquette is 20 ft. in width, and has a slope, for drainage purposes, of 10 to 1, the side slope being 4 to 1. These dimensions of both levee and banquette are increased if the foundation is bad, or the material is not good. In some places the only material available is a very sandy soil, and in such cases a very large section is required. The use of levees as roadways is strictly prohibited.

On approaching the lower end of the levee system, the floods sometimes continue to stand far up on the levees for several months, which tries them very severely, as they become saturated, and easily abraded by wave-wash from wind or passing steamers. To prevent the wave-wash, a plank revetment is fixed a short distance from the levee. After a levee becomes thoroughly saturated with water, a collapse, with its destructive effects, may occur. Such breaks in the levees are called crevasses. When once formed, they continue to increase in width and the rushing flood plays havoc with everything in its wake. Houses, fences, and even the soil itself are torn up, and great damage is done. When a break occurs, but little can be done beyond holding the broken ends, so as to save as much of the levee as possible. So far, efforts at closing a break have not been very successful, and are always attended with enormous expense. Bank erosion is one of the most active and formidable agents in the destruction of levees. A considerable length of completed line often caves into the river, necessitating the construction of a new line farther back, and connecting with the stable ends of the line.

While this great river has few, if any, parallels, the problems are most intricate and interesting; and their solution will doubtless keep the engineer busy for generations to come. Little by little, step by step, the skill of the engineer will find means of overcoming the difficulties, until finally the great forces of nature, pent up in the giant stream, will yield to his bidding, and become subservient to the requirements of man. Then will it, indeed, "flow unvexed to the sea," bearing in safety the commerce of the Mississippi Valley from the great Lakes to the Gulf of Mexico, from whence it will be distributed to the uttermost parts of the earth.

THE WORK OF THE ENGINEER.*

By Jas. Mansergh, F. R. S., Pres. Inst. C. E.

It has long been impossible for any individual to give adequate expression to the fullness of the combination of contemporary science, art, knowledge, and practice which we recognize for engineering. Engineers constitute more than a profession; they amount to a "race," and it is upon them, more than upon any other class of the civil population of the world, that falls the heaviest share of the "white man's burden."

There have been framed many definitions of engineering and of the engineer, but none that I can esteem adequate and at the same time sufficiently exact and exclusive. My reason for holding this opinion is based on two considerations. The first is the persistence of much popular ignorance of the nature of our work, and some lack of appreciation of our class; and the second is the stubborn refusal of the English spirit to admit the necessity of any formal qualification on the part of those who claim to be of the profession. With us—odd as such a state of things must seem to our more highly organized foreign colleagues—an engineer may hold a diploma, or he may not. He may be associated with our Institution, and be entitled to append a string of capital letters to his name, or he may not possess a single title to nominal distinction. This is because engineering with us does not consist in being, but in doing.

The public's unformed, vague idea of an engineer is that of a man who can do things—a great and constantly increasing number of things—all falling within a wide but fairly recognized category. His quality seems to lean more to the side of invention than to that of scholarship. For my part, I am content to have it so. Not than an engineer can ever be too deeply instructed, or too well trained in all the elements of knowledge and skill required for the effective pursuit of his calling; but the really great engineer is born, not made.

So subtle is the influence of words upon thought, that I could wish the name of our avocation were spelt in English, as it is in languages of more pronounced Latin derivation, with a capital "I" instead of "E"—"Ingeniering," say, in place of "Engineering." Thus the nature of our work would be better recognized among the people, who are careless of etymologies. The suggestion of the name would be removed from association with the word "engine" (a good enough word in its degree, and one that once had a wider significance than is now left of it), and would be placed where it rightly belongs, with the root idea which gives us the words "ingenious," "ingenuity," etc.

We must, however, go no further in this direction for the missing definition of engineering or we shall get into the clouds, where, although I am not sure but that we might find some colleges of engineering, we should miss the substance of the thing itself. For engineering is the only high art which depends as much on its cheapness for its excellence as upon any other item in the sum of achievement.

All other things being equal—adaptability, soundness, efficiency—the engineering work which costs the least money is the best. I do not know of any other product of man's creative and adaptive powers of which the same can be so truly said. The "cash" basis is the real foundation upon which the engineer builds, and this consideration draws us at once from judging engineering as merely something cleverly done by an ingenious person. It also very often serves to distinguish between college, textbook, or rule-of-thumb engineering and the real thing.

There is an American definition of an engineer which states that "he is a man who can do well for one dollar things that anybody could do somehow for double the money." This is getting very near the truth. It is not the whole truth, of course, but that, for reasons I have already indicated, is unattainable.

At any rate, it places in due prominence a quality which those who regard engineering studies from the college standpoint are apt to ignore. I have heard a legend of a professor of applied mechanics who was shocked at the thought of steam engines being made to sell for money—like cakes. A good deal of wasted ingenuity would be saved if those who engage in every kind of engineering work would remember to use the money standard, as well as the foot rule and the higher mathematics.

Real engineering must be mastered as it is realized on works in progress. It has no authoritative text-book. The working engineer's library is sometimes largely composed of ephemeral manufacturers' catalogues and lists of prices current of materials. Like the perfect artist described by Longfellow, the engineer must learn to work with the means that lie readiest to his hand. He must cherish his ideals, or he will sink into the routineer, but he, of all men, cannot afford to indulge in hobby riding. He leaves as little as possible to chance, and, if he is wise, he will not rely upon his best mathematics any further than he can see them. If he starts with aptitude, plods on with patience, observes with insight, records with careful exactitude, and adapts with wisdom, in the fullness of time he will find himself, almost to his surprise, in possession of judgment, and that is the glory of an engineer, fitting him for his highest employ as man-of-all-work to civilization.

Material civilization owes much to this faithful servant. Others may plot, scheme, invent, discover wants and their proper supplies; the engineer, as a rule, does chiefly what he is told wants doing. By strict attention to his own business he helps to make the crooked ways straight and the rough places plain for all. The engineer must have great power of concentration. His solicitude is to make every job a little better than the last. The newest steam engine shows a fractional economy of steam; the latest steamship carries her freight with a scarcely distinguishable saving in coal consumption per ton; the selected railway metal lasts a little longer than the previous purchase; the main line is straightened here and there; and, incidentally, as it were, the remote ends of the earth are brought closer together, and plague, pestilence and famine are driven back.

The wiseacres who declare on political platforms that the effect of modern civilization is to make the rich richer and the poor poorer forget all about engineering. The engineer is the chief of the modern democratic civil service.

*Extracts from the Presidential Address before the Glasgow International Engineering Congress.

THE DISPOSAL OF STREET SWEEPINGS in San Francisco, Cal., is being accomplished in a manner which is in some respects decidedly novel. Briefly stated the sweepings are hauled to Golden Gate Park by electric cars and are there used as a fertilizer. All the sweepings from a certain prescribed area, comprising the principal business portion of San Francisco, are hauled by the street cleaning contractors to a central point, where bunkers for receiving them have been erected upon one of the city lots. The bunkers are in the shape of a horseshoe; the two arms of which are constructed on an incline. Teams drive up one of the arms to the top of the platform and return down the other. Around the inside of the horseshoe are arranged a number of bunkers for holding the sweepings, until they can be removed. Along one side of the platform, over the bunkers, trap doors are constructed in the floor. These doors open directly beneath the wagons, which dump at the bottom, and as the sweepings are dumped they shoot down into the bunkers. A switch is laid from one of the electric car lines on the adjacent street and runs between the arms of the bunkers. The bunkers are provided with doors opening just above the car and are constructed at such an incline that when the door is raised the sweepings shoot into the car without further handling. The bunkers will hold 200 cu. yds. of sweepings and from 75 to 100 cu. yds. are deposited there every 24 hours, so that the capacity is sufficient for two days' supply, in case of delay in removing the same. The sweepings are hauled from the bunkers over electric car lines to Golden Gate Park, a distance of about seven miles, for which the street railway company charges 30 cts per cu. yd. At the Park a switch runs from the main car line to an elevated dump, at which point the sweepings are dumped and thence hauled by the Park Commissioners' teams to any desired point in the park. Golden Gate Park consists of reclaimed sand hills which are now for the most part covered with trees and shrubbery. A great portion of the sweepings consist of almost pure manure and they have proved exceedingly valuable as a fertilizing material for the park.

REPAIRING A LEAKING COFFERDAM; AND PILE DRIVING METHODS AT THE LEECH LAKE STORAGE RESERVOIR, MINN.

By W. C. Weeks, U. S. Asst. Engineer.*

The great storage reservoirs at the headwaters of the Mississippi River are created and maintained by the construction of dams across the outlets of the immense lakes, through which runs the main river and its tributaries. The entire reservoir system is under government control, and the original dams were built in 1882-5, when the reservoir country was practically a wilderness. Until the recent construction of a railway within a few miles of the dams, the problem of transportation was a serious one, except during the winter, at which time the frozen lakes and swamps afforded an ideal road for the hauling of material

*Kalispell, Montana.

and supplies on sleds. In this manner, sawmills were brought in and erected near the location of the dams; timber was taken from the nearby forest, sawed into lumber for the building of the dam and the necessary camp buildings as well.

These dams, from the nature of the service required of them, were built for the systematic release of water only; with the necessary addition of a specially-designed sluice for logs. The general design was a round pile foundation supporting a well-laid floor, upon which rested a timber cribwork weighted down with boulders. A row of sheet piles were driven across the foundation in addition to the round piles, and connected to the floor with a water-tight joint. Through the timber cribwork rectangular sluices were left, controlled by suitable gates operated by rack, pinion and worm gearing for high heads, and by stop planks where the head was not too great for their use.

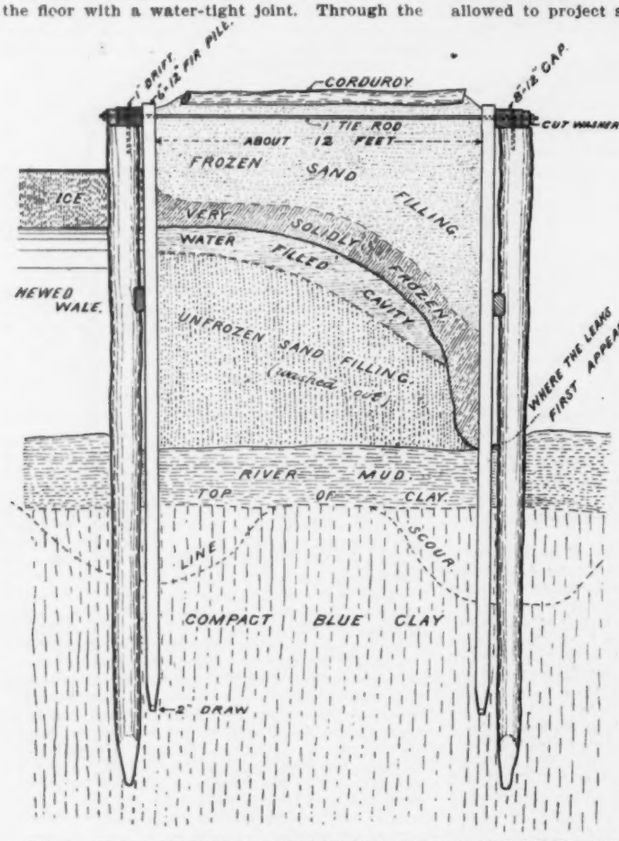


FIG. 1. CROSS-SECTION OF COFFERDAM, LEECH LAKE RESERVOIR, SHOWING MANNER OF FAILURE.

Within the last few years the dams have been showing signs of weakness and decay—the latter, no doubt, hastened because the variable head prevented the complete saturation of the superstructure. It was decided to renew the superstructure with concrete resting upon the original floor, strengthened where necessary by driving additional round and sheet piles. The foundations having been always submerged, are found to be in excellent condition.

Thus far one wooden dam—that at the outlet of Lake Winnibigoshish—has been renewed with concrete piers and abutments and steel framed Tainter gates. At present the reconstruction of Leech Lake Dam is in progress, and the partial failure of the cofferdam at this place is one which is no doubt liable to occur in almost any similarly constructed cofferdam in northern latitudes. Inasmuch as the flowage level of the Leech Lake reservoir is but 6 ft. above its low water level, the reservoir capacity large, and the drainage area tributary thereto comparatively small, it was deemed advisable to construct the cofferdam completely across the river to a connection with the dike which extends for 3,000 ft. across the meadows on the north bank of Leech Lake River. This method of proceeding with the work of construction allows the water on the lower side to drain away so that only a low earth dam, less than 100 ft. long, was necessary to enclose the area to be kept dry by pumping.

The cofferdam as constructed, Figs. 1 and 2, is about 740 ft. long and 50 ft. above the site of the old dam. Round piles of spruce and Norway pine with a minimum diameter of 10 ins., and from 20 to 28 ft. long, were driven solidly through the river mud into the clay or sand beneath, the total penetration being from 12 to 16 ft. The bents are 7 ft. 6 ins. apart and 14 ft. in the clear. At the water surface, 5 ft. below the cutoff, a stout hewed wale was placed; the 8 × 12-in. cap drifted to the piles allowed to project sufficiently to bring the sheet piles vertical. These are of 6 × 12-in. Washington fir. They arrive at the dam in 32-ft. lengths; from each piece was taken all that could be driven, the remainder being used for other purposes. The sheet piles in that portion of the cofferdam sustaining the higher heads were driven nearly to refusal; the penetration, however, will not average as much as that of the round piles by about 3 ft. The driving of the round and sheet piles of this cofferdam was done with a double leader pile-driver especially designed for the work it had to perform.

After the sheet piling had been driven, 1-in. tie-rods were placed at each bent; all bog, etc., removed from the interior, and the cofferdam filled with fine sand, the only available material. Inasmuch as it was necessary to use the cofferdam as a bridge, corduroy was laid on top of the sand filling to protect the tie-rods from passing wheels. All work on the cofferdam was done in dead water, the dam below being closed.

The cofferdam has proved to be remarkably tight; weir measurements of the leakage show the total to amount to about 1-10 cu. ft. per second. It was expected that the work would be completed late in the fall, but unexpected additions and alterations to the floor delayed the concrete work so that it could not be done on account of cold weather. This delay required that the cofferdam should hold over the winter, which was not expected at the time of its construction. At the time the lake froze over the water level was about 2 ft. below the top of the sheet piles. The winter was unusually mild, the lowest recorded temperature being — 36° F., the ice in the lake forming to a depth of about 26 ins. Every precaution was taken to protect the cofferdam from ice thrust. A trench in the ice above the cofferdam 5 ft. wide was maintained all winter, and the arching of the young ice therein showed that motion was taking place in the ice field above. At one point, by reason of the freezing in of a boom, the ice pressure was not properly removed from the cofferdam, until observations showed a marked yielding at that point.

The freezing of the saturated sand filling of the cofferdam caused it to widen at the top, allowing the unfrozen water-soaked material to settle, which, coupled with the normal settlement of the mass, formed water-filled cavities between the frozen and unfrozen portions of the filling. Subsequent observations showed that the filling was frozen, as indicated on the sketch, Fig. 1. After the first few warm days of spring had thawed the material on the lower side of the dam, water from the cavities began to stream through the cracks between the sheet piles, these streams first appearing low down and gradually working up until within a few inches of the water surface above the dam. In this manner, much of the fine sand filling was washed out, and efforts to check these streams were greatly retarded by the solidly frozen arch and corduroy imbedded therein. Holes were cut from the surface to the cavities which were filled with hay and other fibrous material to stop the leaks through the cracks between the sheet piles. In this way the minor leaks were readily controlled, but in the meantime the water had worked its way along to a sheet pile, which, in driving, had become considerably twisted out of place at the bottom by striking some hard substance. Here a leak developed of such magnitude that in a very few minutes from its first appearance all the unfrozen sand filling for a length of nearly 40 ft., amounting to more than 150 cu. yds., was washed out, and the scour threatened to reach to a sufficient depth to undermine the sheet piling. The water flowing through the leak was that which streamed through the cracks in the upper row of sheet piles, and although none of these cracks were large, in the aggregate they supplied a large volume of water.

At first, efforts were directed solely to preventing the scour from undermining the sheet piles on the lower side, in which case the loss of a portion of the cofferdam would have been inevitable. Bags filled with hay, sand and broken stone were cast into the opening, also old blankets and several loads of boulders. This stopped the scour, after which the leak was readily controlled. Additional bags of sand were then placed along the lower inside edge of the cofferdam to weight down the material already there, and to prevent more leaks forming. The frozen arch was then broken down. This portion of the cofferdam now had the appearance of a large tank, the resistance to overturning being due to the cantilever action of the deeply-driven round and sheet piles on each side of the leak. Because of the snow and ice in the channel below, the water on the lower side of the cofferdam could not readily escape, and it rose until the head on the dam was less than 6 ft., which was greatly in our favor.

Fig. 2. View of Cofferdam—Down-stream Side.

A track was laid from the sand pit to the break, and the space refilled. Several minor leaks have since occurred, but by means of the previously described methods they were soon stopped.

In the construction of cofferdams of this plan for service similar to that exacted from the one described, it would seem advisable to batten thoroughly all but the practically watertight cracks, nailing to one sheet pile only to prevent splitting the batters. It might also be well to make the filling next the lower row of sheet piles a layer of hay, straw, sawdust or similar material which, in case a flow did start, would wash into the cracks and form a mat through which the sand filling would not pass. A covering of canvas or old blankets would answer the same purpose. The use of triple-lap sheet piles would render these precautions unnecessary, but the expense would doubtless be greater. The cracks between

the sheet piles were hardly noticeable when they were first driven, and certainly no greater than would be expected in ordinary driving. No leakage, no loss of filling, or trouble of any kind was experienced until after the freezing and thawing of the sand filling. It is hardly possible to restrain the expansion of the freezing filling, for, in anticipation of this, the large cast washers on the tie rods were replaced in the fall with cut washers, and these were drawn deeply into the wood. It is probable that with the large washers, the rods would have been pulled apart. The experience here detailed is not new with this sort of structure. Several engineers have informed me of other threatened failures of similarly constructed cofferdams under the same conditions, which were averted by allowing the enclosed area to fill up until the filling thawed out; but in this case that was impossible.

The double-leader pile-driver illustrated, Fig. 3, was used to drive the round and sheet piles in the Leech Lake cofferdam, and proved so efficient and economical on this kind of work that it would appear well worthy of illustration and description.

The cofferdam has already been described as to its construction. Beginning at the southern end of the dam, the profile along the center line showed a gradual deepening to 8 ft. of clear water in the first channel, then shoaling to a depth of a few inches over a soft muck and bog bottom, succeeded by a few yards of clear water of considerable depth in the second channel, followed by over 200 ft. of very soft marsh and bog. The total length of the cofferdam was 740 ft., and the described conditions at its location precluded the economical use of barge or skids for supporting the pile-driver while at work. Some method of using the driven piles as a support was very desirable, and the single-leader pile-driver on hand was transformed for this special work.

As can be seen from the illustration, the platform of the driver was carried on axles having grooved iron rollers, resting in turn upon long wooden rollers. The platform of the original driver was widened, braced and stiffened by truss rods to provide for the overhang. The leaders were supported by cross timbers bolted to the platform, and braced to each other. In order to get the hammer lines to fleet properly to the single drum of the hoisting engine, a sheave, so hinged as to lead to either headblock was bolted to the platform, through which the lines were alternately passed and fastened to the drum. The rear end of the driver was counterweighted to provide for the 9-ft. overhang. The leaders were 26 ft. high, and placed 15 ft. apart c. to c., this being the distance between the round piles in each bent. The bents were 7 ft. 6 ins. between centers. A light derrick, not shown in the illustration, was subsequently added to the driver, which was operated by the "nigger-drum," and used to facilitate the transfer of caps and stringers from rear to front. The round piles driven in the cofferdam were from 20 to 28 ft. in length; the hammers were each of one ton weight. The driver was remarkably rigid and free from oscillation and vibration, and no accident or delay of any kind occurred while it was in service.

The method of procedure was as follows: A bent of piles having been driven, they were cut off at proper elevation and cross-capped, the cap being raised to place by the nigger-lines from each headblock working simultaneously. The caps were lightly drifted to prevent sliding off the top of the piles, stringers laid on the caps, the driver advanced, and the next bent driven. It will be seen that by first driving the pile in the new bent upon the same side that the last pile in the finished bent was driven only one change of hammer lines was necessary for each two piles driven. As this change was but the work of a moment anyway, no time was ever lost on this account, as the hammer lines were changed while the pile was being raised and centered in the leads.

After the round piles were all driven, the leaders were set closer together and without other change, the driver was ready to drive the sheet piles. These were 6 x 12 ins., Oregon fir, from 16 to 26 ft. long. At this work the driver proved to be particularly efficient, frequently averaging nine piles per hour for an entire day. It will be readily seen that the leaders, being square with the work, permitted the follower blocks or rings to be placed squarely upon the sheet piles and struck squarely with the hammer, which would not be possible with any pivoted device.

It would seem that the double-leader pile-driver, or modifications thereof, is capable of more extended application. It has been suggested that they could be, or have been, used on barges where anchorage was difficult to secure and maintain, one anchorage sufficing for driving as many piles as there were sets of leaders, the latter, of course, being properly spaced. For the rapid and economical prosecution of any engineering work it is essential to minimize the "dead work," and this device is but one of many designed with that end in view.

In Mr. Weeks' latest report to Major Frederic V. Abbot, engineer officer in charge, the plan for the reconstruction of Leech Lake Dam is as follows: The present floor is to be extended about 6 ft. upstream, and faced with a row of triple-lap sheet piling. The wooden superstructure will then be entirely removed, and piers and abutments of concrete substituted. There will be 54 piers, each 4 ft. wide, 10 ft. high and 15 ft. long, leaving 6 ft waterway between them; two other piers will be 6 ft. thick, 10 ft. high, and 15 ft. long, placed 12 ft. apart. The 6-ft. openings are for the discharge of water, and the 12-ft. openings for use as a log-sluice. The abutments will have an extreme height of 13 ft., and a total length of 56 ft. It is proposed to regulate the flow of water by the use of stop-planks, for which suitable slots will be left in the piers.

Fig. 3. Double-leader Pile-driver, Used at the Leech Lake Reservoir.

In this report Mr. Weeks says that the cost of remodeling the pile-driver, referred to above, was only about $75. Up to the end of June 30, 1900, the sum of $6,900.88 had been expended in reconstructing this dam, of which $1,955.28 was charged to the cofferdam.

Owing to the failure of the River and Harbor bill, only a portion of the work was constructed. The abutment and 14 piers, including the log sluice piers, were built and connected by a short cofferdam to the long cofferdam. That portion of the old cofferdam above the concrete work which included that portion which gave so much trouble during the spring was removed, and in this manner provision was made for the control and release of water and the sluicing of logs.

Last summer the plans of Leech Lake Dam were still further modified. The old foundation was lowered 2 ft. by sawing off the piles, a new floor laid and the whole dam shortened. The new dam will be 448 ft. between abutments, have 39 6-ft. discharge sluices controlled by stop plank and one 12-ft. log sluice, similarly controlled. Provision is made for getting these 12-ft. plank down by the use of needles. The piers are 12 ft. high, 5 ft. thick and 15 ft. long; those at the log sluice being 1 ft. wider and longer than the others. The abutments are 15 ft. high opposite the piers, and have a total length of 56 ft.

RESULTS FROM THE USE OF HIGHLY SUPERHEATED STEAM IN ENGINES.*

By R. Lenke.†

Superheated steam is generated by the addition of heat to saturated steam. The behavior of superheated steam is similar to that of gases; it is a very bad conductor of heat, and has the special peculiarity of being able to lose a certain amount of heat without becoming saturated or wet steam. The thermal capacity of steam is only 0.48, therefore very little heat is required to superheat steam; but as the steam loses the heat as quickly as it acquires it, every passage conveying superheated steam must be well covered with non-conducting material. Although there are some losses when using superheated steam on account of the heat radiation, they are very much smaller, because the loss of heat from superheated steam has lower calorific value than the latent heat of saturated steam.

Superheated steam has a greater volume per unit of weight than saturated steam at the same pressure, hence one advantage, and the higher the temperature, the greater this advantage. At various pressures and temperatures the increase of volume may be taken from the following table:

Pressure, lbs.		70	115	170
Temperature of steam,	390° F.*	1.1	1.06	1.02
" " "	570° F.	1.33	1.29	1.24
" " "	750° F.	1.57	1.52	1.46

*Volume compared with saturated steam.

This shows that the higher the pressure is, the smaller the increase of volume; and it is proved from practice that the advantage with lower pressure is indeed greater in proportion than with higher pressures.

The question may arise whether the increase of volume does not require more additional heat than the benefit derived from it is worth. To show this clearly the following table has been prepared expressing how many B.T.U. less are required to produce 1 cu. ft. of superheated steam than of saturated steam at the same pressure. For various pressures and temperatures the total heat per cubic foot (in B.T.U.) is as follows:

Pressure, lbs.		70	115	170
Saturated		233	350	492
Superheated to	390° F.	219	337	485
" "	570° F.	192	297	432
" "	750° F.	175	267	398

That is, to produce, for example, 1 cu. ft. of steam at 115 lbs. pressure and a temperature of 570° F.,

$$\frac{350 - 297}{350} = 15\%$$

less heat is required than would be necessary to produce 1 cu. ft. of saturated steam at the same pressure.

With saturated steam engines, 20% to 25% of admitted steam is condensed during the admission period, consequently the practical steam consumption is very much in excess of the theoretical. Superheated steam does not condense during this period if sufficietnly superheated, hence another advantage.

The economy effected by using superheated steam in engines is very remarkable, and, acknowledging this fact, a great number of steam users all over the world superheat the steam, although in many cases only a few degrees, yet a considerable saving in steam and coal is always the result. To obtain the full benefit, the required temperature of steam is 660° to 700° F., and to stand this temperature, the engines must be specially designed. It is not sufficient to use mineral oil with a very high flash point, and anyone who tries to supply an existing engine of any kind with steam at that temperature will have a very unpleasant experience, even when using the above-mentioned oil.

The introduction of superheated steam into engines largely influences the expansion of the heated parts. Engines always gave great trouble when the distribution of metal in the cylinders was not uniform, as parts with more metal expanded most, and forced the cylinder walls towards the inside and made the cylinder out of shape. When using liners in the cylinders, they were squeezed in at the ends, decreasing the diameter, and jamming the piston body if sufficient clearance was not provided. With steam jackets heated with steam of 500° F., the lubrication ceased as the cylinder walls became too much heated, consequently it was found necessary to do away with jackets, or if jackets were already provided, not to pass steam through them. Pistons constructed on the Ramsbottom type always worked satisfactorily, except in the case of pistons fitted with steel springs, when they were in contact with highly superheated steam. Any kind of gunmetal gets brittle after a very short time, therefore valves, seats, and all parts in direct contact with superheated steam, must be made of cast iron or other suitable mixture. Copper also loses about 40% of its strength at that temperature, consequently copper bends in pipes are not practicable. The best material for piping has proved to be wrought iron and steel, each pipe being as long as possible, to have the least number of flanges. For long

*A paper read before the International Engineering Congress at Glasgow.

†Erith, England.

straight pipe connections, provision must be made to meet the expansion, which is, at 700° F., 0.0037 of the length, so that, for example, 100 ft. of pipe extends 0.37 ft., or nearly 4½ ins.

Glands and stuffing boxes at first frightened users, so the engines were constructed single acting to avoid the use of glands, but no serious difficulties have arisen on that account. It is advisable to place the stuffing box as far as possible from the cylinder end to keep it well away from the hottest parts, and to allow of as much radiation as possible. Sufficient clearance in the neck bush should be made to allow for the expansion of piston rod and no metal with a melting temperature below that of the steam should be used.

Valves and valve gears are influenced in the same way by superheated steam. Valves containing many ribs or different thicknesses of metal (in section), such as plain slide valves or Corliss valves of the usual construction, are not suitable for high temperatures. A Corliss valve of medium size will stand 480° to 500° F., but no more, and the latter temperature very seldom. The smaller the plain slide valves are, the higher temperature they will stand: large slide valves will hardly stand even slightly superheated steam if no provision is made for forced lubrication of the valve face.

Piston valves have proved to be most suitable for the highest temperature, owing to their uniform distribution of metal, but even with this sort of valve certain experience is necessary to get them in good working order. With ground valves, the ribs holding the boss for the valve spindle must not begin within the working surface of the valve, but have to be placed beyond that, because they expand and make the valve polygonal. The valves must be ground in other liners to those in which they are to work in the engine; the former liners have to be smaller in diameter to secure more clearance to provide for the expansion of the valves; all ribs must be placed beyond the working surfaces of the valve. The cylinder expands in length more or less than the steam chest, causing thereby deformation of the latter, which must be carefully considered in design. It is best to work the valves in liners fixed in the cylinder and with a small clearance, sufficient to allow for the deformation of the steam chest. With this construction it is of course necessary to make steam-tight joints between the several parts, and this is best done by stepping the liners and seats and using narrow asbestos rings for each step. The liner is then forced on to the small seats by set screws in the cover, these asbestos rings making a lasting joint. Long valves cast in one piece become scored, whether they are cooled from inside with exhaust steam or not; consequently all valves should be made as short as possible. Rings and springs in valves cannot be recommended, as the steam gets behind the rings and increases the pressure, causing friction and therefore increased oil consumption. As it is impossible to rely on tightness of piston valves, they must be made as small in diameter as possible. It may be stated here that superheated steam can travel at 30 to 40% higher speed through steam ports than saturated steam, and this fact has to be considered during construction.

Two piston valves working one in the other, as the Rider or Meyer valves, are impracticable for superheated steam. If engines of that type are intended to be worked with superheated steam, each valve must work in a separate chamber.

Double-beat valves can also be recommended as being safe, but they require a special arrangement, which is not always obtainable with every gear. Very often it happens when warming up the engines that the valve spindles get hotter than the gland boxes, and on starting the engine, the friction between spindle and stuffing box is greater than the power of the spring, and if the valves are not positively driven, they remain open during the full stroke.

An engine constructed in accordance with the principles just explained, is as safe with superheated steam as any other engine with saturated steam. From the experience of several years, it is not necessary to be bound to single-acting engines.

Besides the economy, the use of highly-superheated steam has some other advantages which are also important. It makes the steam consumption nearly independent of the size of engine, as a small engine has about the same steam consumption as a large one, as for example: an 80-HP. compound condensing engine uses 10.45 lbs. of steam at 160 lbs. pressure, and a 1,000-HP. engine uses 9 lbs. of steam per I.HP. per hour. The use of highly superheated steam does not require high-boiler pressures, 160 lbs. is the highest to be recommended, as no advantage can be derived by exceeding this. As the amount of heat transmitted from the steam to cylinder walls, and vice versa, is much lower with superheated steam than with saturated steam, the whole range of temperature from boiler pressure to vacuum can take place in one or two cylinders, so that the use of a triple-expansion engine does not make the slightest improvement in economy. It is not intended to be understood that the author proposes to do away with all triple-expansion engines, for very large plants, their use will be necessary for constructive reasons.

With regard to economy obtained from engines working with superheated steam, the gain is derived from the larger volume of the steam and the doing away with initial condensation.

Generally the steam consumption of modern engines working under good conditions may be taken as follows:

Single cylinder condensing engines with saturated steam and a pressure of 90-100 lbs. per sq. in. use 19-25 lbs. of steam per I.HP. per hour, corresponding to 373-490 B.T.U. per minute. The great difference in temperature between admission and exhaust steam causes much waste by initial condensation, and consequently this type of engine especially favors the use of superheated steam. With superheated steam the consumption has been lowered to 13½-15 lbs., corresponding to 290-335 B.T.U.

Non-condensing single cylinder engines gave consumptions of 15-18 lbs. of steam per I.HP. per hour, which is about the same consumption as an average compound condensing engine with saturated steam. The non-condensing compound engine decreases the consumption of 14-16 lbs. per I.HP. per hour. The compound condensing engine is the most economical and the economy obtained can hardly be reached by a quadruple-expansion engine working at a pressure of 300 lbs. The steam consumption of such an engine either compound or tandem, at 140 lbs. pressure only, never exceeds 10 lbs. per I.HP. per hour and usually remains below, many tests having shown 8.5 and 8.8 lbs. consumption per I.HP.. To better utilize these temperatures and to work with various loads with safety and nearly uniform economy, Mr. Schmidt has introduced the receiver heater with automatic valve. The idea is to keep a steady mean temperature of cylinder walls not higher than will make the lubrication unreliable for different rates of expansion.

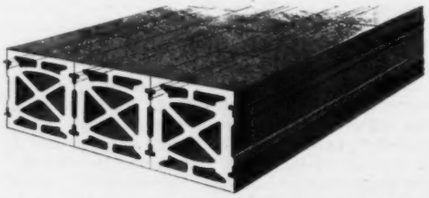
A few words may be said with regard to the cost of a superheated plant. Superheated steam engines use on an average 30 to 40% less steam than saturated steam engines of the same type. Consequently boilers can be made 30% smaller, and the difference in price will nearly cover the cost of the superheater. For the same steam consumption the superheated steam engine is cheaper, as it may be worked with a lower boiler pressure, and it is simpler, i. e., instead of a compound engine with saturated steam, a single cylinder engine with superheated steam may be used, giving the same or better results than the former.

With regard to oil consumption, it is found not to be more than that of an ordinary saturated steam engine. For example: a 120-I.HP. engine used in 24 hours 4 lbs. of oil, and a 300-I.HP. Corliss compound engine 2.2 lbs. in 10 hours for both cylinders.

In view of the great advantages of steam superheating, and the great number of engines running at present satisfactorily, it is astonishing that a few failures have caused prejudices amongst some engineers, who make the general introduction of the use of superheated steam very difficult. It will be worth mentioning that the result of a great number of trials have always proved a great saving in steam and coal, and even with small plants and simple piston-valve engines, almost the same good economy is obtainable as with large engines with most exact valve gears. It is therefore recommended that superheated steam should be used in connection with all engines; the only question to be settled is the degree of superheat, which largely depends on local circumstances, and the construction of the engine, and this matter should be left to the judgment of an experienced engineer.

A CLAY-TILE FIREPROOF FLOOR CONSTRUCTION FOR LONG SPANS.

We illustrate in the accompanying cut a section of a flat arch clay tile fireproof floor construction which has recently been used in a number of buildings in which long-span arches were required. As will be seen from the illustration, the floor is constructed of hollow tile blocks which are keyed together by means of T-irons set in Portland cement mortar. A floor of this type has recently been constructed in the Johnson Free Library Building at Hackensack, N. J., with a clear span of 22½ ft. from wall to wall, no intermediate beams or girders being employed. There is also exhibited at the Pan-American Exposition a floor of 25 ft. clear span of the same construction. The claims made for this construction by the manufacturers, Henry Maurer & Son, of New York city, in a letter to us, are:



Section of Flat Arch Clay Tile Fireproof Floor for Long Spans.
Henry Maurer & Son, New York, N. Y., Builders.

Simplicity of laying (blocks of uniform size); economy of construction (dispensing with steel beams and girders); its thoroughly fireproof character (the T-irons being imbedded in Portland cement and sunk into the terra cotta blocks). The strength and rigidity of this arch have been exhaustively tested, and the construction is approved by the building departments of Philadelphia and New York, and also by the United States engineers, for which we are now erecting at Tompkinsville, N. Y., two office buildings for the light-house department.

RATING AND TESTING OF ELECTRICAL MACHINERY.*

By Gisbert Kapp.†

Electrical engineering enters into so many industries, and has modified the conditions of modern life to so large an extent, that the sale of electrical apparatus has become an important factor in the commerce of every civilized country. To place this commerce on a safe basis it is, however, necessary to arrive at a clear understanding as regards the properties of the different articles bought and sold. This necessity becomes the greater the more the international character of the trade in electrical apparatus is developed, and for this reason the subject of this paper may be considered as specially suited for the consideration of an international engineering congress.

At first sight it may perhaps be thought that the determination of the power, efficiency and other qualities of electric machines is a simple matter. Electric measurements can be made with so great a degree of accuracy that two experts, if they test the same apparatus under the same working conditions independently of each other, must arrive at the same results. Hence, if one expert acts for the seller and the other for the buyer of the apparatus, no difference could seemingly arise. Yet we see it daily that such differences do arise, and the reason for this state of things is that the tests are not made under the same working conditions, and that no general understanding exists as to what shall be tested and how.

As an illustration, the case of a tramway motor may be taken. The manufacturer designates it as capable of developing a certain horse-power. According to his method of rating, this does not mean that the motor is capable of giving off hour after hour and all day long this horse-power. It only means that the motor can, in the usual way of working tramways, give off that power whenever it is required. Now, as a rule the periods during which this full power is required form only a small fraction of the time during which the motor is in service. In such cases it would obviously be bad economy to put in a motor capable of giving off the full power permanently. Yet in other cases this may be necessary. Thus, if the line contain a moderate grade, many miles long, it will require larger motors than a line having very stiff but short grades, yet in the former case the maximum horse-power required is less than in the latter. We thus see that the mere statement of horse-power is not sufficient to decide the question, whether the motor will be suitable for service on a line on which this horse-power is demanded of it. We have here an element of uncertainty in the rating which may cause great trouble to buyer and seller. Another source of difficulties and differences is the question of efficiency, especially in direct-coupled generators. The engine builder guarantees a certain efficiency for the steam engine and the dynamo builder does the same for his dynamo. When the two are coupled it is easy enough to determine the combined efficiency, but it is by no means easy to find out whether each guarantee has been separately fulfilled. Should the combined efficiency fall short of the product of the two guaranteed efficiencies, then the separate determination must be made and each expert will use a different method giving different results. Now, to protect buyer and seller alike it is necessary that the method of testing should be agreed upon beforehand. If the dynamo builder knows how his machine will be tested he can, in framing his guarantee, allow for inaccuracies of the method; the buyer gets his tenders all worked out on the same basis, and can compare them, and the expert who may be called in to test the machinery has no need to invent new methods, but will be simply requested to carry out the tests as agreed beforehand.

Such rules for testing efficiency should be simple and capable of being carried out without entailing great expense or disturbance to the regular working of the plant, and they should give the efficiency with a fair degree of accuracy. Absolute accuracy can, of course, not be expected and is not required; the important point is that by such rules there should be established beforehand a clear understanding between buyer and seller and that there should be no possibility of either being unfairly treated.

It would be easy to multiply examples to show that a general and, if possible, international understanding as to the proper way of rating and testing electrical machinery is very desirable. As, however, on this point

*A paper read before Section III. of the International Engineering Congress at Glasgow.
†Berlin, Germany.

there will probably be no difference of opinion, the author does not propose to take up the time of the congress by giving further examples, but he prefers to put before the congress an account of what has recently been done in Germany in the direction of establishing standards for the rating and testing of electrical machinery.

The Association of German Electrical Engineers, of which the author has the honor of being secretary, appointed last year a committee for investigating the question of rating and testing electrical machinery. The report of this committee was presented to the annual meeting of the association this year and accepted by it provisionally. As is usual with rules and regulations issued by the association, their definite adoption is only decided upon after they have been provisionally in use for a year or two, the object being to provide an opportunity for testing the rules in practical work and for amending or altering them, if the necessity arises, before final adoption, which takes place at some future annual meeting of the association. Thus the "Standards for Rating and Testing Electrical Machinery" are still subject to revision. The committee has been reappointed, with instructions to collect information as to how the standards work in practice, and to bring in a second report next year. In the Appendix is given a translation of these standards. They do not relate to all electrical apparatus, but only to that kind which is generally understood by the term machines and transformers. Thus, generators, motors, rotary converters, motor generators and static transformers are provided for by these standards, but not switches, switch gear, measuring instruments, fuses, automatic circuit breakers and other apparatus. It is not intended that these standards should interfere with any special conditions which buyer and seller may agree upon, but if there are no special conditions previously arranged between the parties, then they shall both be bound by the standards of the association.

As regards the rating of apparatus a distinction is made, according to the time during which it is used. Three classes are provided, namely, for (a) intermittent use, (b) short time use, (c) continuous use.

The same piece of apparatus may be used under all three conditions, but then its rating would be different. Thus a motor which under (c) would be rated at 12 HP. may be rated under (b) as 20 HP. and under (a) as 25 HP. The power is to be stated on the name plate and the test is to be made according to the power stated. Thus, if the motor is rated at 25 HP. for intermittent use, it shall be tested at 25 HP. for one hour. If the name plate bears the inscription 20 HP. for two hours (condition b), then the motor shall be tested for two hours under a load of 20 HP. If the name plate bears the inscription 12 HP. continuous, then the motor shall be tested with that load during 10 hours or a shorter time, if that suffices to bring it to the final temperature. In all three cases the temperature rise must remain within the limits prescribed. These are for cotton-covered wire 50° C., for paper-covered wires 60° C., and for wires insulated with mica, asbestos, etc., 80° C. For tramway motors somewhat higher limits are allowed, namely, 70°, 80° and 100° C., respectively.

The conditions as to overload are not very rigorous. As far as generators are concerned, the capacity to give an increased output is generally limited by the prime mover, and to demand an excess of output beyond that which the prime mover can deal with would uselessly increase the cost of the electrical part of the plant. In motors, transformers and converters, somewhat larger overloads are possible, but then only momentarily, and for this reason the standards only require the overload test to be made during three minutes. The measurement of insulation resistance is not prescribed, but a breakdown test at high voltage. Also this test has been advisedly kept within reasonable limits, since a breakdown test at extremely high voltage may, even if the machine stands it, injure it, just as the cold-water test of a boiler, if made under excessive pressure, may permanently weaken the plates.

The most difficult task of the committee was the framing of rules for testing efficiency. In all eight methods are given, and the maker of the apparatus has the right to specify which method shall be used in testing the efficiency. In framing the methods the committee was guided by considerations of expediency. It would perhaps have been possible to devise methods which, from a theoretical point of view, promise a greater degree of accuracy, but there was the danger that such very perfect methods would entail so large an expenditure of time and money and would cause so much disturbance to the regular working of the plant that they would not be used. Efficiency tests are ordinarily carried out only after the plant has been at work some time. Any test which causes considerable disturbance to the regular use of the plant is therefore inadmissible, and although it would in the interest of science be very desirable to make efficiency tests with the highest possible degree of accuracy, practical considerations must lead us to be satisfied with approximate methods which can be easily carried out. The danger that either the maker of the apparatus or the buyer of it may suffer through the inaccuracy of the efficiency test is provided against by the stipulation that the method under which the efficiency shall be tested must be stated in the tender. Both parties know, therefore, beforehand what sources of error may arise, and the maker of the apparatus can frame his guarantee accordingly.

APPENDIX.

Standards for Rating and Testing Electrical Machinery, Provisionally Adopted by the German Association of Electrical Engineers at the Meeting in Dresden on June 28, 1901.

DEFINITIONS.

A dynamo or generator is a rotary machine for the conversion of mechanical into electrical power.

A motor is a rotary machine for converting electrical into mechanical power.

A motor-generator is a duplex machine, consisting of motor and generator directly coupled.

A converter is a machine in which the conversion of current takes place in one armature.

The word machine used hereunder shall mean either of the above articles, according to the context.

An armature in a machine is the part in which, by the action of a magnetic flux, electromotive forces are developed.

A transformer is an alternating current apparatus without moving parts for the conversion of electric into electric power.

Pressure in three-phase current is the pressure between any two of the three main conductors.

Ratio in transformers is the voltage ratio at no load.

Frequency is the number of complete periods per second.

Rules given for single-phase current apply also, as far as is compatible with the context, to polyphase current.

GENERAL.

1. The following rules shall only apply as far as they are not changed or superseded by conditions of delivery specially agreed upon. The sections 4, 5, 6 concerning the name plates are, however, always to be observed. Machines or transformers without name plates, or with name plates not in accordance with those required, will be deemed not to comply with these standards.

POWER.

2. The power of all machines and transformers is to be defined according to the output. It must be stated for continuous current in kilowatts, and for alternating current in kilowatts, with the addition of the power factor. Motors are to be rated according to the output of mechanical power expressed in horse-power.

In addition to the output there must be stated on the name plate, or a special plate, the normal values of speed frequency, pressure and current.

3. As regards the output, the following working conditions are to be distinguished:

(a) Intermittent use, in which periods of work and rest, each lasting only a few minutes, alternate (motors for crane, hoists, tramcars, etc.).

(b) Short time use, in which the period of work is shorter than necessary to reach the final temperature and the period of rest is long enough to permit the temperature to drop approximately to that of the air.

(c) Continuous use, in which the period of work is long enough for the final temperature to be reached.

4. The power of machines and transformers for intermittent use is to be rated as that power which can be given off during one hour without the temperature rising above the limits stated below. This power is to be stated on a plate with the designation "intermittent."

5. The power of machines and transformers for short time use is to be rated as that power which can be given off during the working time agreed upon without the temperature rising above the limits stated below. This power is to be stated on a plate with the designation "for —— hours."

6. The power of machines and transformers for continuous use is to be rated as that power which can be given off during any length of time without the temperature rising above the limits stated below. This power is to be stated on a plate with the designation "continuous."

7. It is permitted to state the power for different working conditions on the same plate.

8. For generators and converters for variable pressure the plate need only contain the normal values of pressure, current and speed; the limiting values belonging together must, however, be stated in the conditions of delivery.

9. Machines with commutator must, if the brushes are shifted into the best positions, run at any load within the prescribed limits so far sparklessly that no treatment of the commutator with glass, paper, etc., is necessary until after at least 24 hours' working.

RISE OF TEMPERATURE.

10. The temperature rise shall be measured at normal load as defined by the above working conditions, namely: (1) For intermittent use after working one hour; (2) for short time use after working uninterruptedly during the time stated on the plate; (3) for continuous use; (a) for machines after working 10 hours; (b) for transformers after working long enough to reach the final temperature.

11. If with small machines there is no doubt that the final temperature is reached under 10 hours, then the temperature rise may be measured after a correspondingly shorter working time.

12. For testing the temperature rise the various castings or coverings provided for normal working must not be taken away, opened or considerably altered. If for normal work special provision is made for cooling, this may be provided for also during the test, but it is not permitted when testing tramway motors to artificially produce a current of air as an equivalent for the motion of the car.

13. As external temperature is to be taken that of the incoming current of air, or if no current is observable, the mean temperature of the surrounding air about 1 meter distant on all sides and at the level of the center of the machine. The temperature of the air is to be measured in regular intervals during the last quarter of the time of test, and the average of all these readings is to be taken.

14. If a thermometer is used, care must be taken to provide for an efficient transmission of heat between the part to be tested and the bulk of the thermometer by using a bedding of tinfoil. To prevent radiation, the bulb and the part to be measured are to be protected by a covering of a bad conductor, such as dry wadding or waste. The reading must be taken after the mercury has ceased to rise.

15. With the exception of continuous current field coils, all parts of generators and motors are to be tested for temperature rise by means of a thermometer. As far as possible, the points of maximum temperature are to be ascertained and the readings for those points are to be considered in determining the temperature rise.

16. The temperature of continuous current field coils is to be determined from the increase of resistance. Unless the temperature coefficient is specially determined it is to be taken as 0.004 per degree Centigrade.

17. For transformers the highest temperature indicated by the thermometer at any point of the windings is to be taken. If oil be used the temperature is measured in the upper strata of the oil.

18. For ordinary cases and if the air temperature does not exceed 35° C. (95° F.), the temperature rise of insulated conductors, commutators and slip rings shall not exceed the following values:

With cotton insulation	50° C. (122° F.)
With paper insulation	60° C. (140° F.)
With insulation consisting of mica, asbestos, or preparations containing these materials	80° C. (176° F.)

For windings which are not in motion these values may be exceeded by 10° C. (50° F.).

19. In tramway motors, when tested in the testing-room in the workshop after one hour's continuous work, the rise of temperature should not exceed the following value:

With cotton insulation	70° C. (158° F.)
With paper insulation	80° C. (176° F.)
With insulation consisting of mica, asbestos, or preparations containing these materials	100° C. (212° F.)

20. For combined insulation the lower limit must be taken.

21. In windings which are permanently short-circuited the above limits may be exceeded.

OVERLOAD.

22. In practical working overload should only occur for a short time or under such temperature conditions that the permissible temperature rise is not exceeded. With this limitation machines and transformers must be capable of overload within the following limits:

Generators, Motors, Converters	25% for half-an-hour, on condition that in the case of alternators the power factor is not lower than marked on the plate.
Motors, Converters, Transformers	40% during three minutes, on condition that for motors the normal pressure at the terminals is kept up.

The commutator of continuous current machines and converters must not be injured by the test for overload to such an extent that it fails to comply with section 9.

23. If tested at constant speed, the pressure of generators must be capable of being kept constant up to 15% overload, provided that when testing alternators the power factor is not kept lower than stated on the plate.

24. The test is intended to prove the mechanical and electrical capacity to take an overload without regard to heating. For this reason the test is to be begun under such temperature conditions that the permissible temperature rise is thereby not exceeded.

25. These regulations also apply to generators for variable pressure in which the variation of pressure is attained by approximately proportional changes in the speed. In generators with approximately constant speed (which work at normal pressure with a weakened field), the overload test is not to be made. The same applies to motors if they work with a weakened field.

INSULATION.

26. A measurement of insulation resistance is not prescribed, but a test of dielectric strength which has to be made at the makers, and with larger apparatus also on the site before starting the plant. Machines and transformers must be capable of withstanding the test for a half an hour with a pressure exceeding the normal pressure by the amount stated below. The test is to be made when the apparatus is warm, and shall be repeated only in exceptional cases, the object of this restriction being to avoid damage.

Machines and transformers up to 5,000 volts shall be tested for dielectric strength with double their working pressure, but not with a smaller pressure than 100 volts. If the working pressure lies between 5,000 and 10,000 volts, the test pressure must exceed it by 5,000 volts. If the working pressure is above 10,000 volts, the test pressure should exceed it by 50%.

27. The test pressure is to be applied between winding and frame, and for bodily contiguous but electrically separated windings between those windings. In the latter case the test pressure is to be determined with reference to the winding of higher pressure.

28. Two electrically connected windings of different pressure are to be tested to frame with the test pressure corresponding to the winding of higher pressure.

29. If machines or transformers are connected in series, then in addition to the above tests the connected windings are to be tested to frame with a test pressure determined with reference to the pressure in the whole system.

30. The above regulations apply to cases where the testing current is of the same kind as the working current. If continuous current apparatus is to be tested with an alternating electromotive force, then the effective test pressure need only be 70% of the value as above defined. If, on the other hand, alternating current apparatus is to be tested with a continuous electromotive force, then the test pressure must be by 40% greater than above defined.

31. If a winding is normally connected to frame, the connection must be severed during the test. In this case the test pressure is determined with reference to the highest pressure which obtains normally between any point of the winding and the frame.

32. Magnet coils excited from an independent source of electromotive force shall be tested with three times the normal working pressure, but not less than 100 volts.

33. The winding on the secondary armature of an induction motor is to be tested with twice the working pressure occurring at starting, but not less than 100 volts. Squirrel-cage armatures need not be tested.

EFFICIENCY.

34. The efficiency is the ratio of power given out to power put in. It may be determined by direct measurement of output and input or indirectly by measurement

of losses. The indirect methods are more easily carried out, less influenced by errors of observation, and for these reasons to be preferred as a rule. In stating the efficiency the method according to which it shall be or has been tested must be also stated, for which purpose a reference to the corresponding paragraph of these standards is sufficient. The efficiency must be stated for the temperature condition corresponding to normal working.

The efficiency is to be stated with regard to the working condition (compare sections 4, 5, 6). If the efficiency is stated without reference to load, then it shall be deemed to refer to normal load.

The power required for excitation or loss in the field rheostat is to be calculated as a loss when determining the efficiency.

35. For generators, synchronous motors and transformers, the efficiency is to be stated on the supposition of equality of phase between current and pressure.

ary motor. The machine to be tested is given its normal excitation, and the power required to drive the auxiliary motor is determined. The losses in the auxiliary motor (and if a belt drive be employed, the losses in this) are then deducted, having been obtained by measurements and calculations as in section 41. A steam engine can be employed in place of the auxiliary motor if it can be disconnected from the dynamo. In this case the steam engine is indicated when driving the generator at light load at normal speed and excitation, and then the steam engine is indicated again after the dynamo has been uncoupled. The difference between the two indicated horsepowers may be taken as the light load losses of the generator. This method must be used with great care, on account of the inaccuracy of light-load diagrams.

43. INDICATOR METHOD.—If the generator is driven directly by a steam engine and cannot be uncoupled, the efficiency may be determined without regard to friction. The hysteresis and eddy current losses occurring at no load at the normal speed and pressure are determined by taking indicator diagrams with the machine excited and not excited. If the excitation is provided from the same steam engine, the power required for it is to be subtracted. The difference is regarded as loss due to hysteresis and eddy currents, and no account is taken of its variation with load. By means of electrical measurements and calculations the ohmic loss in field, armature and brushes is then determined. Account is to be taken of the fact that the contact resistance of the brushes varies with the speed and current density, and that the ohmic losses of the windings must be calculated for the working temperature. Losses occurring in normal working in field rheostats are to be included in the calculation. The sum of the losses as above determined is called the "measured loss." The efficiency is to be considered as the ratio of output to the sum of output and measured loss. This method must be used with great care, on account of the inaccuracy of light-load diagrams.

44. SEPARATION METHOD.—For machines which have no bearings of their own the efficiency shall be determined without regard to friction in the following manner: The loss due to eddy currents and hysteresis is to be determined in similar manner as prescribed for the "no load method" by running the machine light as a motor. In order to separate the loss due to air, brush and journal friction from the loss due to eddy currents and hysteresis proceed as follows: The machine is to be run without load at different pressure but normal speed. It is advisable to reduce the pressure as far as possible after having taken readings at normal pressure, and, if possible, at 25% excess pressure. The readings are to be plotted graphically, and the curve prolonged backwards to the point of zero pressure. The corfesponding value is the loss due to friction, and is to be deducted from the loss determined at normal pressure. The rest is to be considered as loss due to eddy currents and hysteresis, and no account is taken of its variation with load. The other losses are to be determined as in section 41. The sum of the losses due to eddy currents, hysteresis, resistance of field, armature and brush contacts is called the "measured loss." The efficiency is to be considered as the ratio of output to the sum of output and measured loss. The determination of the losses due to eddy currents and hysteresis can also be made by means of an auxiliary motor.

CHANGE OF PRESSURE.

45. The change of pressure in alternators is to be stated for normal armature current when the load is non-inductive, and for one-third of normal armature current when the load is inductive with a power factor not exceeding 0.3.

46. The change of pressure at non-inductive load is that variation of pressure which is observed on removing the full working load (power factor = 1) whilst not altering the speed and full load excitation.

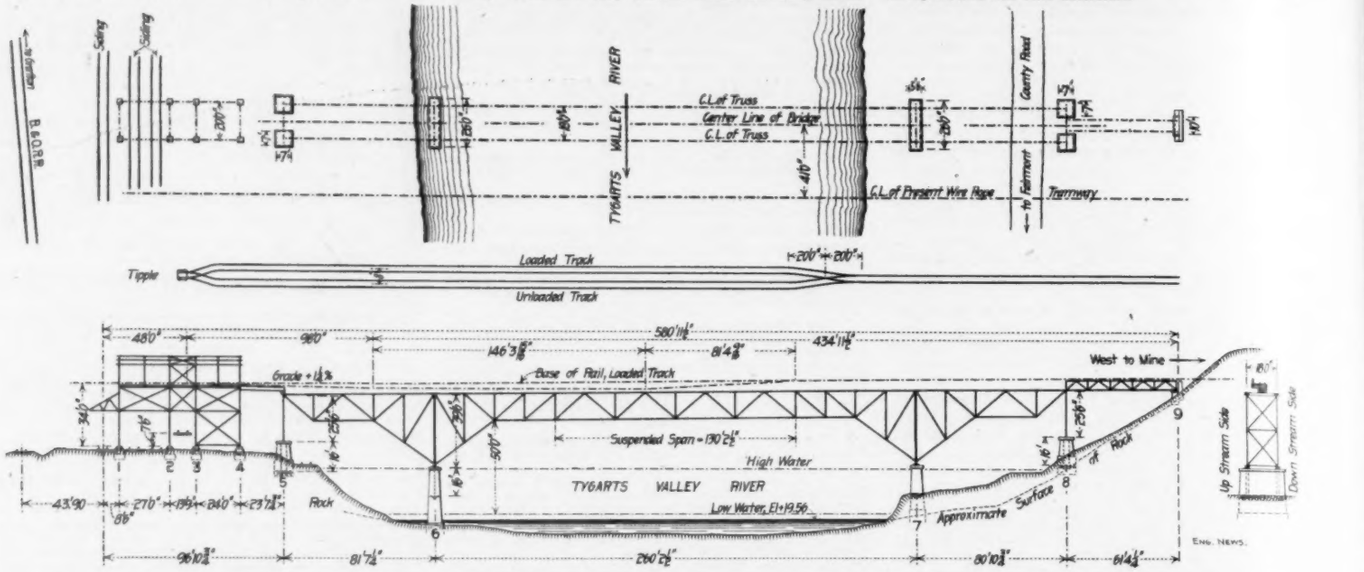


FIG. 1. PLAN AND PROFILE OF BRIDGE AND COAL TIPPLE FOR THE VIRGINIA & PITTSBURG COAL & COKE CO., NEAR FAIRMONT, W. VA.

36. When machines have separate exciters the efficiency of both machines must be given separately.

METHODS FOR THE DETERMINATION OF EFFICIENCY.

37. DIRECT ELECTRICAL METHOD.—This method can be employed with motor generators, converters and transformers by measuring electrically the power put in and given out. In order to employ similar measuring instruments, it is desirable in this method to test similar machines or transformers in pairs.

38. INDIRECT ELECTRICAL METHOD.—If two similar machines are obtainable, they are mechanically and electrically coupled so that one runs as generator and the other as motor. The system is driven by means of current from an external source in such a way that only the power required to cover the losses is supplied and measured. The arrangement is to be regulated so that the mean between the power given to the motor and given out by the generator is as nearly as possible the normal output of the single machine, this average value being determined by measurement. The power supplied to cover the losses can also be applied mechanically and measured electrically.

If belt gearing cannot be avoided in this measurement, the losses occasioned by it are to be taken account of.

The method above described can also be employed with transformers if the latter are identical so far as output, pressure and frequency are concerned. The loss occurring in any auxiliary apparatus is to be taken account of.

39. THE DIRECT BRAKE METHOD.—This method is generally employed for small motors, but can also be employed for a small generator which is being driven as a motor, in which case the conditions must be so chosen that the magnetic and mechanical stresses, speed and output differ as little as possible from what they would be if the machine were used as a generator.

40. INDIRECT BRAKE METHOD.—If a generator or motor of corresponding output is obtainable whose efficiency at various loads is accurately known, this can be employed as a brake or as a driving motor. If a belt drive is employed, the loss in it must be taken account of.

41. NO LOAD METHOD.—The machine is run light as a motor and the loss at normal speed and field strength is determined. This represents the losses due to air, bearing and brush friction, hysteresis and eddy currents whose variation with the load is not taken account of. By electrical measurements and calculations the C^2R loss in the field, armature, brushes and contact resistances at the corresponding load is determined when the machine is warm. In the case of asynchronous motors the losses in the secondary armature may be determined by measurements of slip instead of by measurements of resistance. The losses in regulating resistances in series with the field-windings are to be taken account of. This method may also be applied for transformers.

The sum of the losses determined as above is called the "measured loss." The efficiency is to be considered as the ratio of output to the sum of output and measured loss.

42. AUXILIARY MOTOR METHOD.—If there are difficulties in the way of direct determination of the friction losses as well as of the hysteresis and eddy currents, or if a suitable source of current cannot be obtained for driving the machine, the frictional, hysteresis and eddy current losses may be determined by means of an auxili-

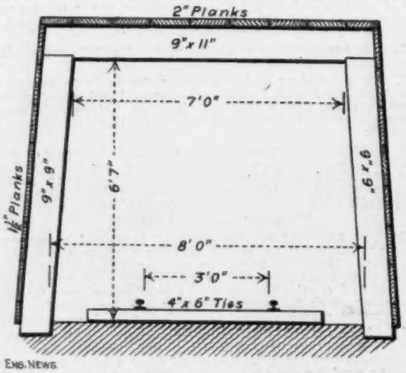


Fig. 2. Cross-Section of Approach Tunnel, Virginia & Pittsburg Coal & Coke Co., Fairmont, W. Va.

47. The change of pressure at inductive load is the variation of pressure which is observed if the armature current is switched off whilst speed and excitation remain unaltered. Before switching off the machine must be loaded to a third of normal armature current, the power factor not exceeding 0.3, and the excitation must be such as to produce at that load normal terminal pressure.

48. Machines for inductionless load need not be tested as described in section 47, and machines for inductive load need not be tested as described in section 46.

49. If continous-current machines are to be tested for variations in pressure, the following is to be observed: Continuous-current machines with shunt, compound or separate excitation are tested at four different approximately equi-distant loads from full load at normal pressure to no load, without the excitation being adjusted. The difference between the greatest and smallest observed pressure is to be taken as the pressure variation. As regards the position of brushes during this test the same practice as agreed on for ordinary working shall be adhered to.

50. For transformers the ohmic loss of pressure and the short-circuit pressure with the normal secondary current has to be given, both for the secondary circuit. The ohmic loss is taken to be the pressure variation for inductionless load; the short-circuit pressure as the pressure variation for inductive load. It is permissible to make the test with a current differing slightly from the normal, in which cases the variations in pressure must be calculated proportionately for normal current.

COAL TIPPLE AND CANTILEVER BRIDGE OVER TYGART'S VALLEY RIVER, NEAR FAIRMONT, W. VA.

We illustrate in the accompanying cuts the general plan and some of the more notable details of the new surface plant recently erected by the Virginia & Pittsburg Coal & Coke Co., of Fairmont, W. Va., for operating its coal mines. These mines, comprising 1,200 acres of coal lands, are located on the west bank of the Tygart's Valley River at Kingmont Station, about three miles above Fairmont, W. Va. The coal seam outcrops at an elevation of about 110 ft. above the water in the river. On the opposite side of the river from the mines are the tracks of the Baltimore & Ohio R. R., over which the company ships its coal to market. This location of the mines and the railway on opposite banks of the river necessitates the transportation of the coal across the river, and for some ten or twelve years past the company has carried its coal across the river by means of a wire ropeway running from the mouth of the mine to the tipple. This method of transportation has been tedious and expensive, and in 1900 it was decided to bridge the river and erect

an entirely new surface plant of substantial construction. The plans for this plant were prepared by Mr. Charles Worthington, Assoc. M. Am. Soc. C. E., Consulting Engineer, of Pittsburg, Pa., under whose direction all work of construction was done.

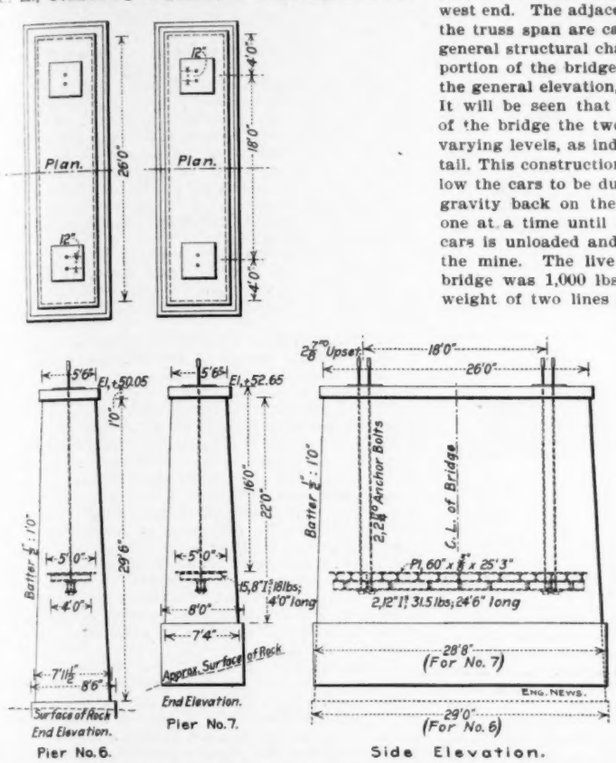


FIG. 6. PLAN AND ELEVATIONS OF PIER, SHOWING ANCHORAGE CONSTRUCTION, VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

The general arrangement of the plant as designed is shown quite clearly by Fig. 1. The river is spanned by a bridge which terminates on the bank of the river opposite the mines in a steel frame tipple. The approach to the bridge from the mines is through a tunnel which penetrates the ridge intervening between the west bank of the river and the mine workings. This new tunnel entrance was considered desirable in order to avoid a steep grade on the bridge, which might result in wrecks due to cars becoming unmanageable while approaching the tipple. The approach tunnel has a grade of 2% and a length of 416 ft. Fig. 2 is a cross-section of the tunnel, which was through rock and which had to be lined to prevent the rock from scaling off and causing wrecks.

The bridge across the river is a cantilever structure, with a short deck truss approach span at the west end. The adjacent ends of the cantilever and the truss span are carried on a rocker bent. The general structural characteristics of the cantilever portion of the bridge are sufficiently indicated by the general elevation, Fig. 1, and the view, Fig. 3. It will be seen that on the double track portion of the bridge the two tracks are at different and varying levels, as indicated by Fig. 4 in more detail. This construction was adopted in order to allow the cars to be dumped by gravity and run by gravity back on the siding or "unloaded" track one at a time until the entire "trip" of 20 or 30 cars is unloaded and coupled up for returning to the mine. The live load used in designing the bridge was 1,000 lbs. per lin. ft., this being the weight of two lines of loaded mine cars. Fig. 5 is the stress sheet for one-half of the bridge. One track being below the other, the exposed wind surface on the cars was equal to nearly double that on one line of cars. First-class construction was adopted throughout with a view to stiffness and durability.

Cooper's specifications for highway bridges were used for unit stresses, details of construction and workmanship. The material was medium steel, conforming in quality and manufacture to the requirements of the Manufacturers' Standard specifications as given in the "Carnegie Handbook" of 1897. No inspection of material was made at the mills, but the manufacture of the material was subject to the approval of the engineer. The Carnegie Steel Co. furnished all material for the structure. Rivets were used in all connections throughout the work, excepting, of course, at the top and bottom of rocker posts and at the connections of the suspended span to the cantilever arms, where pins were used. The diagonals were made shorter than calculated length between end holes to the extent of 1-16-in. for every 10 ft. of length. Special care was taken to avoid eccentric connections wherever possible, and stresses transferred through a group of rivets, as in connections, were required to have their center line pass through the center of gravity of the group, thus causing the group to act as a unit, and without straining one rivet more than another. This principle was also applied to the material in gusset plates.

A priming coat of pure raw linseed oil was given all steel work at the shops, and after erection two additional coats of oxide of iron paint, the paint used being No. 31 of the National Paint Works, of Williamsport, Pa.

The substructure masonry was first-class coursed ashlar of native sandstone, laid in a mortar of two parts sand and one part Louisville Black Diamond natural cement, all joints being pointed with a rich Portland cement mortar. Fig. 6 shows the anchorage construction adopted.

The tipple building is of steel throughout, covered above the floor with corrugated iron and equipped with the Phillips Mine Supply Co.'s patented push back dump and standard West Virginia screens, and also with a wooden bin capable of storing some 25 or 30 tons of coal. The drawings of Figs. 7 and 8 show a number of the special details of the tipple construction. It will be seen from Fig. 1 that the tipple storage bin is arranged to dump into cars on a track beneath. This track serves to take the coal to the company's coke ovens, which are strung along the river bank above the tipple.

The total capacity of the plant as constructed is from 2,000 tons to 2,500 tons of coal loaded on cars per day. The contractor for the superstructure was the American Bridge Co., Pittsburg Branch, and Mr. M. C. Hite, of Fairmont, W. Va., was the contractor for the masonry and the tunnel work. We are indebted to Mr. Worthington for the information from which this description has been prepared.

FIG. 3. GENERAL VIEW OF BRIDGE AND TIPPLE FOR VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

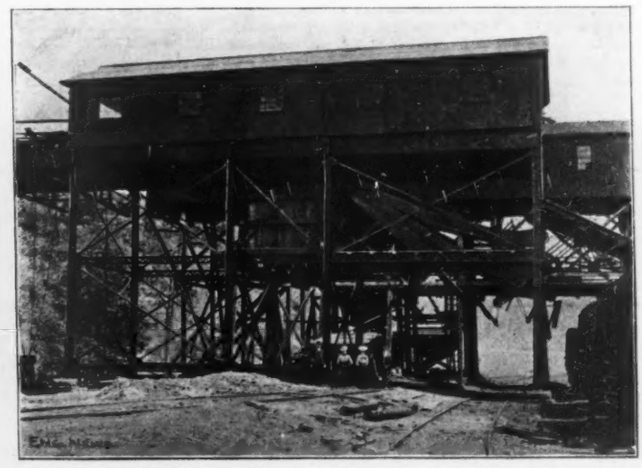


FIG. 9. GENERAL VIEW OF COAL TIPPLE FOR VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

THE MANAGEMENT OF SEPTIC TANKS AND BACTERIAL CONTACT BEDS.*

By Gilbert J. Fowler, M. S. C., F. I. C.†

In spite of the dismal forebodings of some, there can be no doubt that bacterial methods of sewage purification are destined to come more and more universally into use. The reason for this is, as the President of the Section has often said, that bacterial treatment is the only practicable method by which real purification of sewage—i.e., conversion of putrefactive organic matter into harmless inorganic forms—is effected.

In speaking of bacterial methods, land treatment either by irrigation or downward intermittent filtration is, of course, included. In the majority of cases, however, especially in the large northern towns, suitable land is not to be had in sufficient quantity, and some method by which larger volumes of sewage can be dealt with per given area becomes a necessity. It has now been definitely proved: (1) That a thoroughly well purified effluent can be obtained day after day for years, without exception, by purely bacterial methods; (2) that trade refuse, with but few exceptions, exercises little or no influence on the purity of the effluent; (3) that a large proportion of the sludge can be dissolved or converted into gas.

Investigation is now chiefly concerned with ascertain-

*From a paper read before the Royal Institute of Public Health, and published in the London "Contract Journal."

†Superintendent and Chemist, Manchester Corporation Sewage Works.

ing in detail the most economical as well as efficient methods by which sewage may be purified, not merely experimentally, for a short time, but on the large scale, for long periods of years. The following observations are the result of experience with experimental plant, and with septic tanks and bacterial beds on a working scale.

It is not proposed here to deal exhaustively with the relative merits of septic treatment as against direct treatment of raw or settled sewage on bacteria beds, nor with the respective claims of contact beds and continuous filters. It may simply be remarked that in Manchester much higher nitrification can be obtained by the treatment of sewage in the septic tank, followed by contact beds, than by any of the other methods. In other places higher nitrification may be obtained by continuous filters than by contact beds. The choice of one or the other method is partly a question of the special character of the sewage dealt with, and partly a question of expense, determined by local conditions, cinder supply, necessity for pumping, etc.

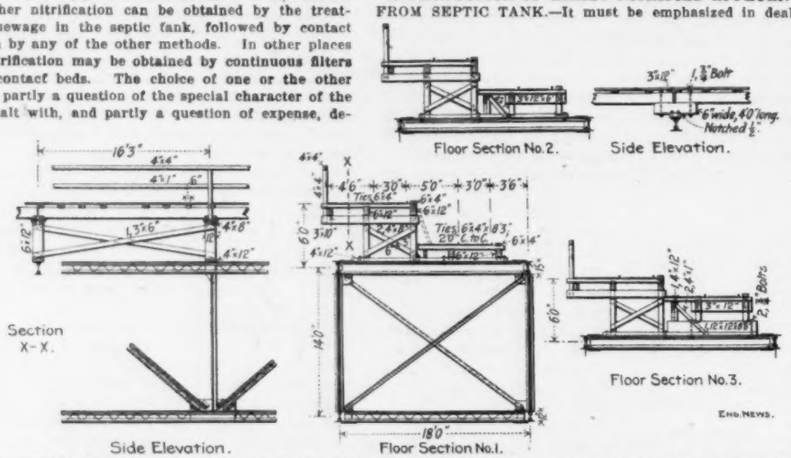


FIG. 4. TRANSVERSE SECTIONS OF MAIN SPAN OF BRIDGE SHOWING FLOOR CONSTRUCTION, VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

THE MANAGEMENT OF SEPTIC TANKS.

The objects of careful management of septic tanks will be: (1) To dissolve or gasify as much sludge as possible; (2) to obtain a tank effluent in which the matters in solution are easily nitrified; (3) to produce a tank effluent with little suspended matter; (4) to avoid creating a nuisance. Taking these points in order:

1. DESTRUCTION OF SLUDGE IN SEPTIC TANK.—It must always be remembered that no bacteria have yet been discovered which will consume mineral matter. In all cases, therefore, where road detritus is mixed with the sewage, ample catchpit accommodation should be provided. I have heard of a sewage committee who were so enthusiastic for the septic system, that in spite of the protests of their manager they abolished all catchpits before their septic tanks, saying that if they were to have septic treatment, it should be "gradely." Unfortunately, their manager's fears were realized, and their tanks rapidly silted up, and their enthusiasm for septic treatment is probably on the wane.

Having provided grit chambers, it is necessary that they should be cleared out at frequent intervals, or they cease to be catchpits. The size of catchpit will depend on local conditions, the frequency of cleansing, on the weather, most of the grit coming down in storms. If the catchpits are too small, all the grit will not be arrested; if too large, sludge, which might otherwise have been bacterialized, will be taken away with the grit. Besides grit, it is, in my view, well to screen out bits of wood, rags, etc., as such cellulose material is only very slowly attacked in the septic tank. All such matters, together with the grit, cinders, unburnt coal, etc., which is often present from boiler house drains, should, if possible, be burnt. Wherever it can be done, it will be advantageous to have the town's refuse destructor set up at the sewage works; all catchpit and screen refuse can then be burnt with the town's refuse, and a supply of clinker obtained for bacteria beds. Having removed insoluble substances from the sewage, it will be possible to obtain a higher percentage destruction in the septic tank.

It will be found that on starting a new septic tank (as in the case of a bacteria bed) that the action begins slowly and gradually arrives at a maximum. It is important, therefore, that the ultimate flow should not be passed through the tank at first, lest sludge should rapidly accumulate before septic action is established. When one septic tank is fully at work, another may easily be started by pumping into it enough sludge from the first to just cover the bottom. I fear it will not be possible for one authority to supply another with septic sludge to inoculate their tanks, as the amount which can conveniently be carried by rail is not enough for the purpose. I once by request sent a barrel of septic sludge to another town, and heard that it had exploded en route.

2. PRODUCTION OF EASILY NITRIFIED EFFLUENT FROM SEPTIC TANK.—It must be emphasized in dealing with this point that by no means the least important function of the septic tank is to so change and break down the soluble constituents of the sewage that these are readily nitrified when put upon bacteria beds. Even if but little reduction in sludge took place, this action alone would justify the use of septic tanks. If the flow through the septic tank is suddenly increased during a time when the sewage is at full strength, fresh sewage may find its way on to the beds, and will fail to be purified, for it has been definitely established that beds which have become accustomed to septic sewage will not at once purify fresh sewage, and vice versa. Apparently unaccountable changes in the efficiency of bacteria beds may sometimes be traced to this cause. An increased flow of sewage diluted by rain may be safely put through, as in this case the proportion of organic matter per gallon will be less. It is also quite possible, I believe, to work a septic tank too slowly, and produce a putrid effluent which is actually poisonous to the nitrifying organisms. Possibly some complaints of the nuisance arising from septic tanks may be due to this cause. The exact rate of flow to be adopted will depend on local conditions.

3. REDUCTION OF SUSPENDED MATTER IN SEPTIC TANK EFFLUENT.—The ultimate product of septic action upon sludge, besides the soluble substances above mentioned and the gases methane, carbonic acid, hydrogen, and nitrogen, is a very finely divided suspended matter, partly of the nature of humus, partly mineral—e. g., finely divided clay, or sulphide of iron (if iron salts are present in the sewage). This tends to pass away with the effluent, and on to the bacteria beds.

To avoid this result, an attempt has been made in Manchester to remove the fine suspended matter by a special pipe communicating with the grit chamber. By such a device it is hoped that the two insoluble products, the grit on the one hand, and the humus on the other, may be taken away together from time to time without disturbing the action of the tank. The experiment has not been tried long enough to definitely decide as to its success, but so far there seems no reason why this arrangement should not effect the object in view.

4. AVOIDANCE OF NUISANCE.—A good deal of apprehension has been expressed as to the possibility of nuisance arising from septic tanks, and it is certainly a matter for serious consideration. The residual sludge and grit, if removed as suggested, can be pressed and used for manure or burnt. The silt alone is quite inoffensive, and if tipped is rapidly converted into a dry sandy heap. Covering the tank is not a real prevention of the nuisance, unless the gas evolved is collected and burnt. The heat from it may find useful application in drying the sludge, etc., before it is sent to the destructor above mentioned. The value of the gas for this or other purposes will go a long way towards defraying the cost of covering the tanks. In Manchester, Leeds, Accrington and other places however, there is, singularly, little smell either from the open tank, or from the sludge.

MANAGEMENT OF CONTACT BEDS.

The management of contact beds should be directed towards (1) the production of a pure effluent; (2) the maintenance of capacity; (3) minimum expenditure of labor.

1. PRODUCTION OF A PURE EFFLUENT.—(a) Equable Composition of Septic Tank Effluent.—One of the chief factors in producing a good contact bed effluent or filtrate is the absence of great variation in the composition of the septic tank effluent. The importance of this has already been indicated when speaking of the management of the septic tank, and will be more easily achieved if manufacturers can be induced to send down their refuse in a steady stream, and not in intermittent flushes. In most cases there is little difficulty in obtaining their co-operation to this end. Successful bacterial treatment of sewage will need certain restrictions to be enforced as to what may or may not enter the sewers, but for the most part these restrictions are already embodied in the Public Health Act Amendment Act, and are not such as to press unduly upon manufacturers, It is often to their advantage that their trade refuse should be under careful supervision, as unsuspected sources of waste are often discovered by this means.

(b) Thorough Drainage of Bed.—The thorough drainage of a bacteria bed is of the first importance in securing a good effluent. If the water cannot get out the air cannot get in, and the lower parts of the bed rapidly become putrid and the nitrates decrease, perhaps are quite absent. Further reference will be made to drainage when considering the question of capacity. Here it must be emphasized that when the nitrates decrease (and simultaneously there will always as a rule be an increase of nitrites), the beds must be rested. With experience, a modification of the three minutes' oxygen absorption test may be adopted as an index to the efficiency of the bed, which may be put into the hands of a workman to carry out. For a given sewage there is generally a pretty constant relation between the three minutes' oxygen absorption test, and the other determinations, ammonias, nitrates, etc. If an acid solution of permanganate of known strength is made up in the laboratory and given to the filter foreman, with a measuring glass, by mixing known quantities of the contact bed effluent and the permanganate solution, he can readily ascertain the character of the effluent by the rapidity with which the permanganate is decolorized.

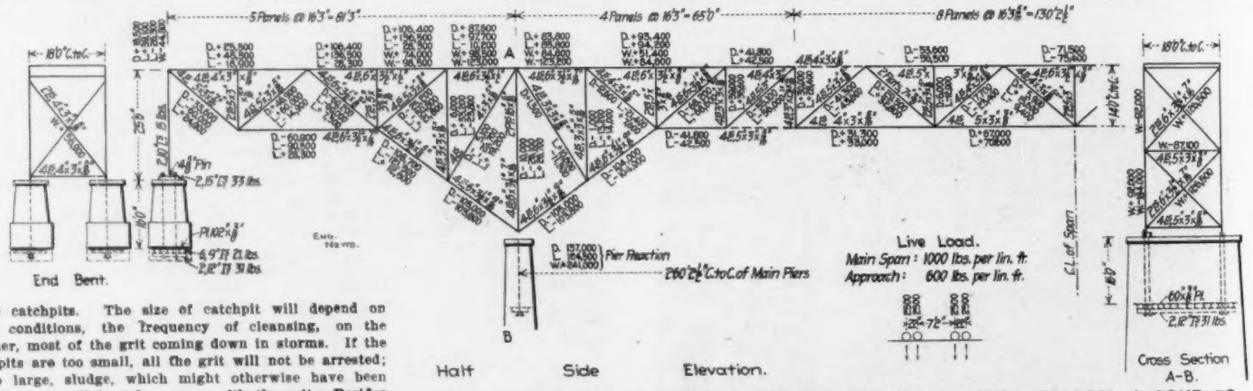


FIG. 5. STRAIN SHEET FOR BRIDGE FOR VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

2. MAINTENANCE OF CAPACITY.—It is quite possible for the effluent from the bed to continue excellent in composition although the bed may be falling off very much in capacity. Careful note must therefore always be made of the time of filling under identical conditions if more accurate methods of measurement are not available, and if it begins to rapidly decrease the bed must be rested. The chief causes of less capacity are the following: (a) Settling together of the material; (b) growth of organisms; (c) impaired drainage; (d) solid matter entering the bed; (e) breaking down of material.

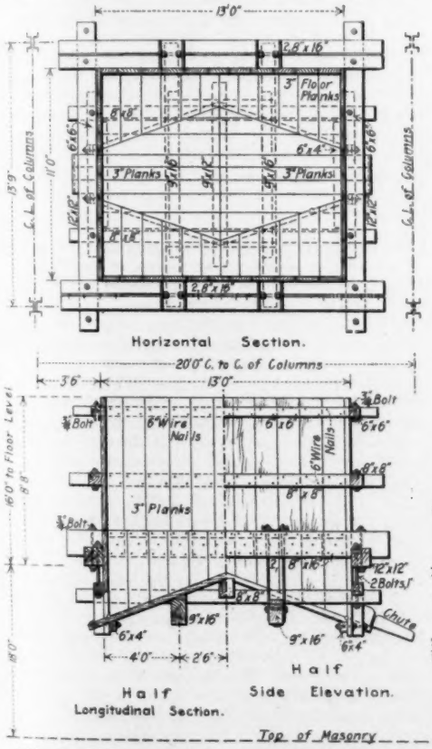
(a) Settling Together of Material.—This must always

occur, and largely accounts for the initial rapid decrease in capacity after the bed has been at work for a short time. It may, indeed, often be necessary to put an additional quantity of material upon the bed to maintain the surface at its original level.

(b) Growth of Organisms.—This is at once the cause of increased efficiency in the bed and of loss of capacity. On examining the material of a contact bed in active condition, every piece of it—clinker, coke, whatever it may be—will be found coated over with a slimy growth. If this is removed it is found to be a stiff jelly, which, after a little drying, can be cut with a knife. Before examining under the microscope it should be treated with dilute acid to remove as much as possible of any hydrated oxide of iron present. It will then be found to consist of masses of bacteria and zoogloea. If placed in a tube containing air and connected with a manometer, the jelly will rapidly absorb all the oxygen with production of carbon dioxide. This action will sometimes produce a vacuum equal to 6 ins. of mercury. This experiment shows that there is little need to force air into a bed. As a matter of fact, there is always a large amount of oxygen to be found in the bottom of a bed in good condition, owing to the interchange of gases which naturally takes place.

The behavior of the bacterial jelly appears to afford a clue to the successful working of bacteria beds. By working them at high speed—i. e., filling them frequently in the day without long periods of rest—the effluent may remain good, but the bacterial growth so rapidly increases that the bed becomes too spongy, and will not allow the water to drain away. Here, too, is the explanation of the fact that, within limits, decrease of capacity is accompanied by increase of efficiency. This decrease of capacity may, however, become so great as to more than outweigh the advantage of increased efficiency. A long period of rest, say one or two weeks, must then be given to the bed. The superfluous bacterial growths will during this time be rapidly consumed, and the capacity of the bed will greatly increase.

Increase of capacity due to this cause is not a merely temporary phenomenon, produced by the drying of the bed. One of the Manchester experimental beds, for instance, sank in capacity during the winter of 1899-1900 to such a low point as 1,480 gallons (the capacity at the beginning of the experiment being 4,200 gallons). At the present time, after 15 months have elapsed, during which the bed has been in regular use, its capacity under



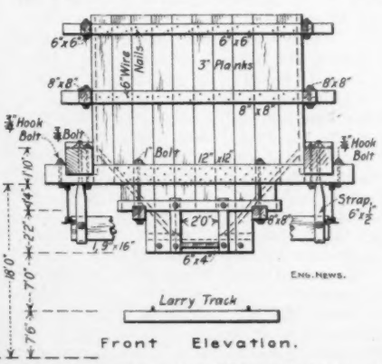


FIG. 8. DETAILS OF STORAGE BIN FOR COAL TIPPLE, VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

similar conditions of measurement is 2,000 gallons, and it has not yet reached its full summer capacity. This result has been brought about simply by judicious periods of rest. It has been found in the course of experiment that these should not exceed a fortnight at most, as the bed then tends to dry up and the activity of the organism ceases.

These results cause me to think that the policy of pushing the working of the bed to its utmost extent and frequently washing the material, as recommended by Dr. Dunbar, of Hamburg, is not really satisfactory. By washing the material the bacterial jelly is removed, and will have to be reformed before the bed is completely efficient. The time spent in washing, if given to rest the bed, would probably produce an almost equal rise in capacity, when the initial period of slow working required for regaining the efficiency of the washed bed is taken into account.

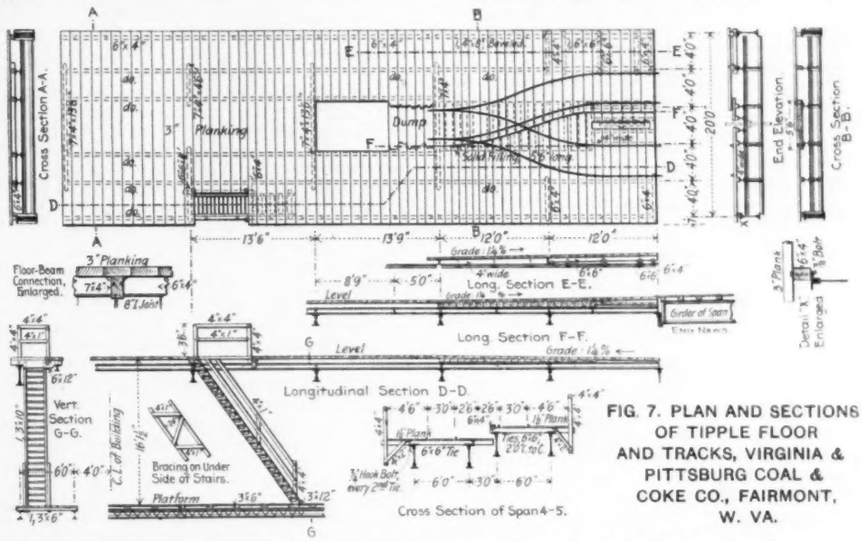


FIG. 7. PLAN AND SECTIONS OF TIPPLE FLOOR AND TRACKS, VIRGINIA & PITTSBURG COAL & COKE CO., FAIRMONT, W. VA.

(c) Impaired Drainage.—This matter has already been dealt with in speaking of the causes which tend to deteriorate the effluent. It cannot be too strongly emphasized that every care should be taken in designing the bed to make the drainage as efficient as possible. There should be no opportunity given for the finer particles of the material to work down and block the interstices of drain pipes, etc. The half-acre beds which are being constructed in the Manchester scheme are provided with radial channels all converging to the exit penstock. The channels will be covered with perforated tiles or cement blocks, and over these will be placed at least 1 ft. of large lumps of clinker.

(d) Solid Matter Entering Bed.—The decrease of capacity owing to solid inorganic matter entering the bed is not necessarily great, inasmuch as this material, especially if of a sandy nature, has itself a water holding capacity. Its character will depend on the locality—i. e., whether the district is gravelly or clayey, etc. In any case the dry capacity of the bed will not be greatly affected. The danger is that the interstices of the bed may be filled up with clayey mud, which in the wet state will hold up the water and so decrease the wet or working capacity. This loss of capacity will not be affected by resting, and therefore all such solid matter should be retained as far as passible on the surface of the bed, and removed from time to time. It will be found to constitute excellent soil, as it will contain nitrates and phosphates from the sewage, and cabbages and other vegetables will readily grow upon it. A way is open here to allay the fears of agriculturists who view with alarm the impoverishment of the land following upon modern methods of water carriage of sewage.

(e) Breaking Down of Material.—A more serious cause of loss of capacity than any of the foregoing is the disintegration of the material of the bed. This should be avoided at all costs by using only hard refractory material. When clinkers are used, as will probably be most commonly the case, such only as are hard and well fused should be put into the bed. All shale and ashes must be rejected. As a matter of fact the ordinary weathering which an old cinder tip undergoes, will generally have resulted in the disintegration of all but the harder portions. On screening, therefore, the fines will retain most of the softer material.

To summarize the foregoing: For the successful working of bacteria beds, the following method of procedure will be calculated to give the best results. The bed must be worked very slowly at first, in order to allow it to settle down and the bacterial growths to form. In this way there will be less danger of suspended matter finding its way into the body of the bed while the material is still loose and open. The burden should not be increased till analysis reveals the presence of surplus oxygen, either dissolved, or in the form of nitrates, in the effluent. Analyses of the air in the bed may usefully be made from time to time during resting periods.

Also the variations in the capacity should be carefully recorded. If the capacity is found to be rapidly decreasing, a period of rest should be allowed. Long periods of rest should be avoided during the winter, as when deprived of the heat of the sewage the activity of the organisms decreases. If necessary, the burden on the bed should then be decreased by reducing the number of fillings per day, rather than by giving a long rest at one time.

The suspended matter may be retained on the surface by covering the latter with a layer of finer material not more than 3 ins. in depth. This should not be raked into the bed, but when the amount of suspended matter retained becomes excessive it should be scraped off. This suspended matter may be tipped and made use of for agricultural purposes. By placing the inlet and outlet penstocks as close together as possible, the suspended matters will tend to concentrate at this point, and their removal will be facilitated.

After many years, it may, in spite of all precaution, be necessary to wash a portion, at any rate, of the material. It should not be difficult to devise a machine by which this may be easily and cheaply done, purified effluent water from a neighboring bed being used for the purpose. This mud so washed out will readily dry, and may be also used for raising vegetables.

3. THE MINIMUM EXPENDITURE OF LABOR.—Unfortunately, data for the actual cost of maintenance of bacteria beds are still limited. Experience with experimental beds, at Manchester and at Oldham, where several acres of beds have been at work for upwards of three years, shows that it should be by no means excessive. Facilities should always be provided in designing beds for the economical removal of material from the surface.

The evidence all points to the conclusion that with careful management, founded on chemical and bacteriological knowledge, the sewage even of large manufacturing towns may be efficiently and economically purified by bacterial methods. Thus we may look forward to a time when the unsightly cinder heaps of our manufacturing districts will be removed to find useful application in purifying the vast volume of their waste liquids. As a consequence large open spaces will once more be set free, which may be utilized for the good of the community. Further, by careful removal of the surface of the beds from time to time, the nitrates and phosphates may be largely recovered from the sewage, and in a perfectly inoffensive form be returned for the service of agriculture. At the same time the standing reproach of our civilization which is presented by the abominable condition of the rivers and streams near our large towns would be removed, and science show itself equal to the demands made by the ever-changing problems of social development.

have 40 ft. likewise. But before this is in sight New York will be back with an appeal for 50 ft. to put her ahead of her competitors, and Bath and Newport News and Savannah and Cumberland Sound and a dozen others will be clamoring for deep enough water to compete with Boston and Baltimore and Philadelphia.*

This is no fancy sketch; it is the actual situation with respect to River and Harbor appropriations. Is it not time to draw a line somewhere in national appropriations sought on account of commercial rivalries?

Of course, the stock argument in favor of the progressive deepening of channels and harbor entrances is the increase in the size of ships; but there are two large factors in this problem that are frequently overlooked. The first is that the size of general cargo vessels is still far below the scale set by the few huge transatlantic liners of the past three or four years. The average gross tonnage of the vessels passing through the Suez Canal in 1899 was only 3,830 tons. Doubtless the great vessels of 10,000 tons displacement and upward are destined to play a larger and larger part in ocean transportation; but no matter what the depth of water offered by a port, such vessels will only be run to great commercial cities, where a cargo can quickly be secured. The existence of such vessels is no argument for spending money to deepen the channels of minor ports to accommodate such huge vessels.

Another fact, too often overlooked, is that it is little use to deepen American harbors beyond the depth prevailing in foreign ports; and while these, like our own, are being improved, the work proceeds at a slow rate. Liverpool and London are England's two greatest ports; yet in both these the largest vessels have to wait a favoring tide to enter or leave.

We call attention to these facts, not with any desire to oppose meritorious works for harbor improvement, but because these works ought to be fairly judged on their merits. It is being urged, for example, that if the appropriations are to be cut to $13,000,000, the whole amount ought to be spent on the larger ports, and the "creeks" should be abandoned. So far as this means the cutting off of appropriations which were made merely to give each Congressional district a slice out of the pork barrel, it is in the right direction. If, however, it means cutting off really important and needed work in the smaller harbors, to give the great cities help in their rivalry with each other for the export trade, it is emphatically in the wrong direction.

That cheaply-built macadam roads may also be cheaply maintained is the contention of our contributor, Mr. H. P. Gillette; and in a paper on another page of this issue he tells how the village of Albion, N. Y., a place of about 5,000 inhabitants, has paved its streets with macadam, and is maintaining them in good condition at surprisingly small cost. The figure named by Mr. Gillette as the cost of maintenance is only $90 per mile per annum for both labor and material. As we have frequently pointed out, the great expense of maintaining macadam roads, as that work is ordinarily done, is the greatest deterrent to their general use. Mr. Gillette's contention that this work of maintenance can be done at far lower cost than that ordinarily allowed is worth the careful attention and study of every one interested in road construction.

ENGINEERS AND PATENTS.

Our comment last week upon the probable invalidity of existing septic tank patents may bring to some minds the larger question as to the position which the engineering profession should take with relation to patents. Upon this question the most conflicting views are held.

One view is well set forth by a distinguished civil engineer in a recent personal letter, from which we quote as follows:

> It is a very poor engineer who in his practice does not from time to time improve on stereotyped methods, using as a basis his own experience and the published experience of other men. But rarely are these improvements patented and they should not be, for the original work of each man is but a fraction of the whole.
>
> From time to time patents for engineering methods are issued. Almost invariably those which I have seen are either old processes or non-patentable improvements or advances on well-known processes, but the patent covers the entire process. The result is that engineers are either prevented from using that method at all, or have to go to the courts. Apparently there is no engineering expert examiner in the Patent Office, and it would seem that patents are issued for any engineering process not on record there.
>
> In many instances the patents do not stand the test of the courts, when finally brought there, but it requires time, money and trouble to thus break a patent, and in the meantime the profession suffers.

The view was very commonly held in former times that it was in some degree unprofessional conduct for an engineer to seek to patent inventions or improvements which he might make. In the medical profession, it has always been held a serious breach of the code of ethics for a physician to seek to patent or claim any exclusive control over any medicine or treatment which he might devise. So in the engineering profession it has been likewise held to be the duty of the practising engineer to give freely of his work for the benefit of his professional brethren, and refrain from patenting any improvements which he might devise in the course of his work.

This view, if we mistake not, is much less commonly held now than it was twenty or forty years ago. It has been all but swept away with the expansion which has taken place in the engineer's field of work. The mechanical engineer and the electrical engineer have never had any professional qualms on the subject of patents; and if one were to go over a list of civil engineers and strike off all those whose names appear on the patent records, he would find that the list would suffer a very large reduction, and that among those who have taken out patents are civil engineers of the widest reputation, and those who have achieved the highest professional honors.

Again, the taking out of patents on minor improvements is objected to in the letter quoted above, and it is urged that while the inventor may make only a trifling improvement on the work of previous inventors or on previous well-known engineering practice, his patent covers the entire process. On this point, however, our correspondent is misinformed. The man who makes a trifling improvement is strictly held down by the Patent Office to just that trifle and no more. His drawings and specification may, indeed, cover the entire process; but the claims of his patent, which strictly define and limit the boundaries of the field over which he may claim a monopoly, are restricted to just what he has actually done to advance the state of the art. So strictly is this done by the Patent Office and by the courts, in fact, that it really constitutes a hardship to the genuine inventor. It often happens that a man makes an invention of great value and importance, and is unable to obtain patent protection as broad as the merit of his invention deserves, simply because some other prior inventor has used some of the important elements of invention. The prior use, in nine cases out of ten, will consist merely in a more or less vague description and illustration of these elements in some existing patent which has never been put into practical use at all. Yet it acts as a complete bar to the deserving inventor, nevertheless.

It is true, as our correspondent says, that the Patent Office relies chiefly on existing patents in its search to determine the novelty of an application, and hence patents are sometimes issued for inventions which are in common use, but which have never been patented. Cases of this sort are not common, however, for either the inventor, his attorney and the examiner, have all more or less general knowledge, as a rule, of the state of the art; and a patent on anything which has been in public use is an invalid document, and of no value to the inventor.

Finally, it may be asked what course the engineer should pursue who desires to adopt a certain design and finds his way blocked by a patentee who demands a royalty for its use. We will suppose, as in the case cited by our correspondent, that the engineer believes the patentee to have no real and valid claim to compensation. The first thing to be done is to obtain a copy of the patent under which compensation is claimed,* and scrutinize its claims carefully to see whether the design proposed will actually infringe them. Many times it will be found that no infringement will occur, or that the design can readily be altered to avoid infringement. If, however, neither of these proves to be a way out of the difficulty, search may next be made to determine what the chances are of the patent's validity. A complete set of all the patents issued to date in the subclass where the invention occurs, may be obtained from the Patent Office, for only 3 cts. per patent. Examination of these will frequently show weak points in the patent which it is desired to upset. Copies may also be obtained of the complete proceedings in the Patent Office in connection with the grant of the patent by paying merely the cost of copying. These papers will disclose what the office examiners considered the weak points in the inventor's position. If these searches disclose nothing affecting the validity or breadth of the patent, and if no previous public use of the invention is known, it is safe to say that the patentee has a pretty good case, and that if his invention is made use of he will be fairly entitled to a reasonable compensation.

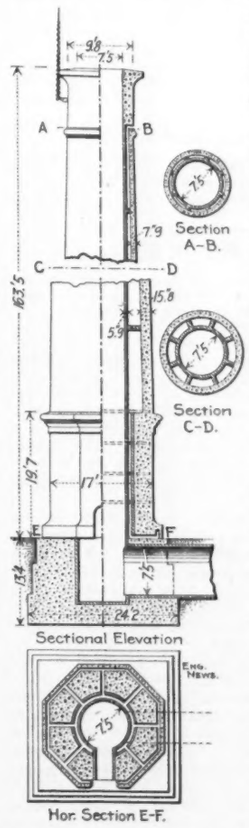
*Even as we write there comes to our notice the announcement of a projected "deep-water convention" to be held at Gulfport, Miss., in November, for the purpose of urging Congress to appropriate $1,500,000 to deepen the Gulfport harbor entrance from 26 ft. to 30 ft.

*The Patent Office will send a copy of any U. S. patent for 5 cts.

LETTERS TO THE EDITOR.

A Concrete Chimney at Bellinzona, Switzerland.

Sir: Having been informed that a concrete chimney some six years of age had been built in Italy or Switzerland, I endeavored to secure some definite information in regard to it by correspondence. The result was the finding or locating of a chimney, with a shell built of concrete blocks and the core of clay material such as ordinary red bricks, in Bellinzona, Switzerland, which was built and patented by Messrs. Mariani Batista & Co., of Milan. After being in use for six years this chimney is in very good condition. Its height is 35 meters (114.8 ft.), and it cost 2,250 francs. The builders say that they have built a great many with good results.



The exterior mantel or shell of the chimney is formed of insetted, or armed cement prisms, joined by cement mortar. The base is so constructed, that to avoid cracks in the outer shell the cool air may enter from without and pass between the shell and the core. The dimensions of the cement blocks are about $0.25 \times 0.20 \times 0.15$-meter, and vary with the general dimensions of different chimneys.

My attention has been called to many American brick chimneys in which the outer shell and flue core were united at the top, and in which the top exterior has been raised clear of the balance of the outer shell by the great heat within the flue. This type of chimney (see the accompanying illustration) is so planned that the top with its ornamentation is incorporated with the inner flue, and thus is independent of the outer shell, and the chimney cannot receive damage from the temperature of the escaping gases, so far as the top is concerned.

Wm. Wallace Christie, M. Am. Soc. M.E.

Paterson, N. J., Aug. 14, 1901.

How Not to Thaw Dynamite.

Sir: The recent occurrence of several dynamite explosions brings to mind an experience of mine some 13 years ago while in a Western mining camp. I was one day

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The bereavement which this nation has just suffered, through the death of its chief ruler by an assassin's bullet, brings to the mind of every thoughtful man the fact that the greatest and best works that our civilization has created—and what of these is greater or better than man himself in his noblest estate—are at the mercy of depraved and degenerate individuals of the race. Mingled with the emotions of sorrow and of reverence for the honored dead at this time is the impulse to remove this danger that threatens those in high position. The attack on the President was more than the murder of a great and noble man. The assassin's pistol was aimed at him not from enmity, but because he was the representative of a nation. It was a blow struck at organized government. How to reduce this danger is a problem that may well engage the thoughts and efforts of our wisest statesmen; and if it leads to study and solution of the larger problem as to how the prevalence of the crime of murder may be reduced, the death of the martyred President will not have been wholly in vain.

This is not the place nor the time to discuss this question further than to briefly note that Society must turn away from the idea of punishment and toward the idea of prevention in order to make headway against the forces which war against it. It is folly to confine confirmed criminals for a brief period and then let them loose to renew their career of law-breaking. The anarchist who counsels murder and incendiarism as a means of reforming social conditions brands himself as an enemy to Society, and unworthy of a place in it.

We cannot hope to wholly remove such dangers, try as we may. There will always be individuals of weak minds in whom the passion for murder or murderous destruction may be set aflame by any one of a thousand causes. Civilized society can and should purge itself, however, of at least the worst of the evil elements which now war against it; and it must adopt some better method than mere temporary incarceration inside prison walls or sending the criminals of one nation outside its own borders to prey upon another. There may yet be a return to the old-time plan of penal colonies for those who have forfeited their right to a place in civilized society.

We reprint in this issue a number of the valuable and interesting papers presented at the International Engineering Congress, held at Glasgow during the first week in September, as one of the features in connection with the Glasgow Exposition. Among these, the paper which we judge will be of the largest practical use is that on the rating and testing of electrical machinery, in which the rules adopted in Germany to govern this matter are given in full. Those responsible for the drafting of specifications for electrical machinery will doubtless find these rules a valuable guide.

The paper on "Workshop Methods" indicates how closely English competitors are watching progress on this side of the Atlantic, and adopting those features which have won such fame for American machinery during the past few years. Both these papers, together with several others which we reprint on mechanical topics, were read before Section III. of the Congress, which was in charge of the Institution of Mechanical Engineers of Great Britain.

In the Section devoted to Waterways, Mr. J. A. Ockerson presented an interesting summary of the work in progress on the lower Mississippi. While the paper was written for a foreign audience, this work is so little known to American engineers outside of the few who have taken part in it, that we have reprinted a large part of Mr. Ockerson's paper.

The Presidential address of Mr. James Mansergh so abounds with wise and witty sayings that none of our readers should miss it. His sarcastic references to engineering colleges and professors, are meant, doubtless, to apply to the English article. We are accustomed to flatter ourselves that we do these things better here; yet some American engineering schools will do well to see how the man at the head of the Institution of Civil Engineers regards fine-spun theories and abstruse mathematics. His blunt remark that the engineer, if he is wise, will not rely upon his best mathematics any further than he can see them, contains a world of common sense.

An amusing illustration of the character of the news concerning technical matters which the daily press serves to the public is the reference to this Congress which has appeared in American newspapers. Out of the half a hundred papers, more or less, which were read before the Congress, one alone struck the eye of the American press representative as worthy of note; and this one was Mr. James Barton's account of the Irish Channel Tunnel project. As our readers will recall, we reviewed this enterprise in our issue of May 23 last, and showed its Quixotic character. Mr. Barton in his paper, also, frankly set forth some of the difficulties in the way, and acknowledged the financial impracticability of the enterprise at present. Of course, this part was omitted by the newsgatherer, and the man who makes the "scare headlines" did the rest. Thus, so far as the general public in America is concerned, the International Engineering Congress was chiefly notable for its description of the Irish Channel Tunnel, which is shortly to connect England and Ireland by an indissoluble tie!

It reminds us of a convention of the American Society of Civil Engineers, at which a reporter picked up one stray remark in the course of a discussion. The morning papers in all parts of the country next day announced that at the American Society of Civil Engineers' meeting it was stated that the locomotive of the future would be built like a bicycle, run by electricity, and equipped with rubber tires.

We take pleasure in calling attention to the able and practical paper on "The Management of Septic Tanks and Bacterial Contact Beds," presented by Mr. Gilbert J. Fowler to the recent meeting of the Royal Institute of Public Health and reprinted, nearly in full, elsewhere in this issue. The connection of the author with the investigations of sewage treatment at Manchester, England, carried on for several years past, has given him a fine opportunity to study the new methods of sewage purification on a working scale. As a result, he presents a number of conclusions and suggestions which should be of much value to many engineers and to superintendents of sewage disposal works. For the points made by Mr. Fowler readers are referred to the paper itself, where they are expressed in a clear and concise manner. The paper prompts us to say that the septic tank appears to have gained for itself a far more certain position than the contact filter bed, both in England and America. There are as yet comparatively few contact filter beds in the United States, and most of those are small. Soil naturally adapted to intermittent filtration is plentiful in many sections of the United States, and filter beds can be constructed at comparatively low cost. On the other hand, we scarcely know what material to use, in America, for contact filter beds, and have practically no information in relation to their cost of construction or operation. In fact, in neither England or America are there any very definite and reliable figures on the cost of the various new bacterial systems of land treatment. Until such figures are made available, and until more is learned regarding the permanency of the filter beds, it will not be strange if American engineers continue to be conservative in the matter of abandoning intermittent filtration.

A convention is to be held in Baltimore on Oct 8 and 9 to promote River and Harbor Improvements, or more specifically to urge Congress to make liberal appropriations for carrying on this work. If such a convention could be held which would be really representative, and which could and would discuss the subject with an intelligent appreciation of the national point of view, as well as the local, it might perform a very useful service. Such conventions, however, are not apt to be thus conducted. The delegates severally know what their respective cities or districts want, and know and care for nothing else. If the size of River and Harbor appropriation bills were left to such conventions as these to determine, it would not take long to empty the United States' Treasury.

It is reported from Washington that Secretary Root has cut down the estimates of the Corps of Engineers, which are to be presented to Congress, so that the aggregate for River and Harbor work is only about $13,000,000. We beg to suggest that the Baltimore convention, when it meets, should proceed to discuss how this sum of $13,000,000 ought to be divided among the different harbors and waterways which will claim consideration. Such a subject will make the proceedings interesting, even if it does not tend to peace and harmony, and the delegates' time will be more profitably and intelligently employed than it would be in passing the usual cut and dried resolutions respecting the greatness of commercial development and the duty of the nation toward the water transportation interests.

If the Baltimore convention still wants matter for deliberation, we venture to suggest the following question: Where shall we draw the line in the use of the national treasury for the benefit of competing rivals? In other words, we have come to the point where all the ports on the Atlantic coast want Government work done purely to help them in their rivalry with each other.

New York's harbor entrance was improved a number of years ago to give about 30 ft. depth and she was very well satisfied until Baltimore and Philadelphia and Galveston had their channels improved to admit large vessels. Then New York went to Congress with an appeal for 40 ft. and came back with $5,000,000 or so to make a channel of that depth. Then Boston and Philadelphia and Baltimore and the other ports joined in declaring that they were as much entitled to an entry for the biggest ships as New York, and there will be no peace for Congress till these all

and not one-half of them are still in operation; that all have been financial failures, and that "Boston, Washington, and New Orleans, and other great cities have tried the experiment and want no more of it." We have already shown that it is unnecessary to go below cities of over 200,000 inhabitants to find nine in which reduction works were in operation in 1900, and we may here add that in cities of from 100,000 to 200,000 population, there were four more such plants in use. A small plant at Boston was closed down a few years ago, but a much larger one of the same system was afterwards built and

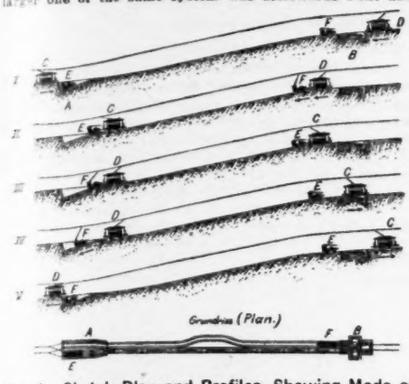


Fig. 1. Sketch Plan and Profiles, Showing Mode of Operation of Electric Cable Railway at Palermo, Sicily.

has been in operation ever since. A reduction plant at Washington was burned down some years ago, and although that particular one was never rebuilt, and though one or two crematories were subsequently erected, or contracted for, a second reduction plant was completed at Washington only a short time ago. This is not included in either the nine or the four plants named above, since only such were selected for those lists as were presumably in operation when the author wrote his American chapter.

It remains to be said of the American chapter that an introduction to it was contributed by Mr. W. F. Morse, of New York, a man connected with garbage cremation almost from its inception in the United States. If proofs of the American chapter had been submitted to Mr. Morse surely some of the criticisms noted above would not have been required. The five pages by Mr. Morse are interesting and suggestive. He makes no such sweeping assertions relating to reduction as are found in the subsequent pages, but it is well for the reader to remember that he, like Mr. Goodrich, has long been engaged in building garbage furnaces.

Of the two concluding chapters, the one describing and illustrating English refuse destructors gives a good general idea of the details of each type and make of furnace and contains a number of summaries, in tabular form, of various destructor tests. The final chapter is chiefly devoted to such practical subjects as the most economical method of charging cells, the prevention of chimney dust, the utilization of furnace residue, and the collection of refuse.

The subject of garbage disposal is receiving so much attention in this country at present that such a book as this should be heartily welcomed; not, as will be readily understood, on account of its American chapter, although

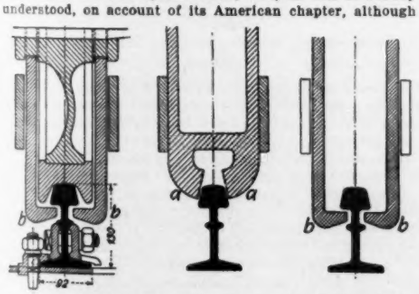


Fig. 3. Details of Track Brake on Auxiliary Motor Car, Palermo Electric Cable Railway.

some omissions and corrections would make this quite useful, but because of the large amount of information relating to the British furnaces, which certainly seem to lead the world both in numbers and excellence.

MARINE DIRECTORY OF THE NORTHWESTERN LAKES.—Harvey C. Beeson, Royal Insurance Building, Chicago, Ill. Cloth; 7 × 10 ins.; pp. 264; illustrated. $5.

The main feature of this annual publication are the detailed lists of steam and sailing vessels, their dimensions, builders and owners, and a similar list of types and dimensions of engines and boilers. A new feature of this edition, however, is a list of Canadian steamers on the lakes. There are the usual lists of casualties, ore docks, shipping owners, etc., and a list of yachting associations and clubs, marine associations, etc. Besides this matter of important information for the shipping interests, there are special articles on the lumber industry, admiralty litigation, gasoline launches and other interesting matter. A useful feature is a classified directory of shipbuilders and dealers in marine and engineering supplies. The volume is handsomely printed and profusely illustrated by halftons and line engravings of steamers, scenery, portraits, etc.

A NOVEL ELECTRIC CABLE RAILWAY AT PALERMO, SICILY.*

A remarkable cable railway operated by electricity is in operation between Rocca and Montreale, near Palermo, on the island of Sicily. The road is nearly straight and is about 6,700 ft. long, with a total rise of 603.5 ft. The grade for 720 ft. at the beginning and for 2,600 ft. at the end varies from 2% to 8%, but over the intermediate portions it reaches a maximum of 12%, so that the ordinary motor cars, which are used on the Palermo streets, cannot surmount it. In order to avoid a transfer of passengers over the steep grade, two special brake cars, thoroughly equipped with safety appliances, are attached to the two ends of a cable that is led over a guide pulley at the upper end of the grade. The regular cars are then coupled, one to each of the brake cars, which are fitted with electric motors, and are then run over the grade.

Fig. 1 shows the principal movements as they occur. The ascending motor car is indicated by C., the descending by D; the ascending brake car by E and the descending by F. An arrow beneath the cars indicates the direction of their motion. At I we have the brake cars in their waiting positions: car E is in the pit at station A, and car F is in front of the pit at B, in which the cable pulleys are placed. The motor car D then passes over the pit and is coupled to the brake car F. The motor car C also passes over the pit at A and stops in front of the brake car E. At II the cars F and D, under the operation of their motors have moved down the grade until the cable has drawn the brake car E up against the motor car C to which it is coupled. By a further movement, under the influence of all of the motors, the weight of the descending cars balances that of the ascending and the latter are thus enabled to climb the grade while the speed of the former is under control.

As the gage of the Palermo Street Ry. is but one meter (3 ft. 3⅜ ins.), the width over all of the brake cars (Fig. 2) must be less than that and it has been fixed at 3 ft. 1¾ ins. The distance between the wheels on the axles has been crowded down to 1 ft. 10 13-16 ins. The framing for the cars must also be brought between these distances so as to give the strongest possible support to the track brakes, which are shown in outline in Fig. 3.

Ordinary Vignole rails are used for the motor cars. The two tracks are arranged as shown in Fig. 4 for the greater portion of the distance over the steep grade; that is to say, the tracks for the regular cars have the inner rail in common. There is a double track for passing at the center and at the pit A. All of the rails are laid on iron crossties.

*Condensed from an article in "Zeitschrift des Vereines Deutscher Ingenieuer" for May 25, 1901, by Geo. L. Fowler, M. Am. Soc. M. E., 53 Broadway, New York city.

The brake cars are shown in outline in Fig. 2. The electric motor A is placed on top of the upper frame, and has the two worms B_1 and B_2 keyed to its shaft. These latter mesh with the worm wheels C_1 and C_2 which, by means of a pair of spur wheels D_2 and E_2, turn the car axle.

Especial attention has been paid to the matter of brakes. Each of the four wheels is fitted with a set of tong brakes, of which one part a exerts a downward pressure upon the rail while the part b comes to a bearing beneath the rail head with an upward pressure as shown in Fig. 3. These opposite motions of the pieces a and b are effected by means of a knee joint shown above the axle in Fig. 2.

The brakes on the rear pair of wheels are set by the motorman by means of a brake handle F; those on the front wheels are applied by the fall of the weighted lever G. This lever is held by the tension of the cable which takes hold of the lower end of the double-armed lever H. By the relaxation of the cable due to breakage or any other cause the brakes will be automatically applied to the forward wheels. At the same time the electric circuit is broken so that the motor is converted into a generator and the current produced is spent in resistance.

TEXAS PETROLEUM.

The Bulletin of the University of Texas, No. 5, contains a lengthy and detailed description of the petroleum development in Texas, written by William Battle Phillips, Ph. D., professor of field and economic geology in the university, and director of the Texas Mineral Survey. From this report we obtain the following interesting information:

Up to and including 1895, the total production of petroleum in the state only amounted to 361 barrels; in 1899 this production rose to 669,013 barrels; and in 1900, to 836,039 barrels. His orical reference to tar-springs and oil "seeps," however, extends back—possibly to the first occupation of the country by the Spaniards. A natural lubricating oil in Texas, "similar to that of West Virginia," was reported upon in 1886 by Mr. Jos. D. Weeks, in "Mineral Resources of the United States;" and he particularly referred to the Nacogdoches field, discovered about 1867 by Emory Starr and Peyton F. Edwards. Shallow wells then drilled failed to reach the true oil deposit, though pumping wells were opened in 1887 and 1890.

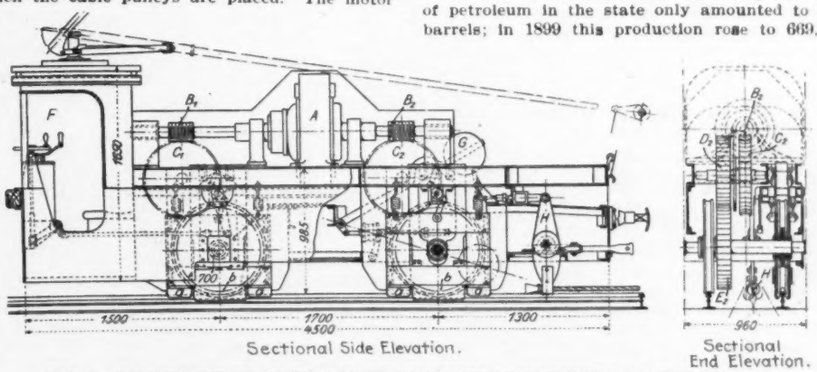


FIG. 4. DETAILS OF CENTERING USED IN LINING MUSCONETCONG TUNNEL.

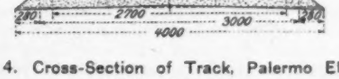


Fig. 4. Cross-Section of Track, Palermo Electric Cable Railway.

The first attempts to find oil in the now famous Beaumont region were made in 1892 by Patillo Higgins; but owing to lack of proper machinery and knowledge the well was carried down only 300 ft. and then abandoned. The development proper of this field began on Jan. 10, 1901, when A. F. Lucas applied his experience in sinking wells in the salt districts of Louisiana, and opened the first Lucas well, 3½ miles south of Beaumont. This well was commenced in October, 1900, and struck the oil deposit at a depth of 1,120 to 1,139 ft. The oil-jet rose to an estimated height of 300

engaged in thawing out some sticks of dynamite, and had placed them in the oven of our cook stove to facilitate the operation, for as all miners will tell you, "fire won't explode the devil's candies." Even the oven method being too slow, I took one of the sticks in my hand and held it over the hot lid of the stove, turning it slowly between my fingers. Suddenly I perceived a drop of nitroglycerine clinging to the end of the stick and in my eagerness to remove the stick as rapidly as possible from the field of danger, I jarred the drop loose; as it fell it exploded like a pistol shot, cracking the stove from oven to lid, allowing red-hot coals to fall upon the dynamite in the oven, which immediately took fire. To say that I considered not the order of my going but went is a trite literary way of picturing my departure. I ceased running only when a quarter of a mile of mountain scenery lay between me and the cabin.

Upon turning around what was my horror to see a companion rushing foward the cabin which from the volume of smoke issuing he took to be on fire; and, despite my warning yells, he proceeded to shovel snow into the door and upon the stove to smother the fire. Presently, smelling the characteristic glycerine smoke the impromptu fireman abandoned his role as fire extinguisher and his shovel and he too made footprints in the snow that actual measurement afterward proved to be 10 ft. 6 ins. apart. Never before had I realized that the reflex action of so powerless an element as smoke acting upon the olfactory organs could develop an energy certainly not less than ⅓-HP.!

However, no explosion followed, and the dynamite quietly burned up; but I think there is a very important principle to be deduced from this experience, to wit: While fire will not explode dynamite directly it will do so indirectly by thawing the glycerine until it oozes from the stick and a drop then falling—even a few inches—will explode by detonation, which in turn may explode the dynamite.

Many accidents have happened in thawing dynamite before open fires, and on stoves, and I am convinced that the above is an exact account of how such accidents occur. It gives me great pleasure to have witnessed the phenomenon and to be able to impart the knowledge to the engineering world otherwise than through the medium of spirit rappings. He who thaws and runs away may live to thaw another day—but not dynamite.

Halbert Powers Gillette.

Rochester, N.Y., Aug. 31, 1901.

Notes and Queries.

Copies of Engineering News of Jan. 17, 1901, are desired by the Book Department of Engineering News, and 20 cts. each will be paid for any copies sent to us in good condition.

BOOK REVIEWS.

THE ECONOMIC DISPOSAL OF TOWN'S REFUSE.—By W. Francis Goodrich, A. I. Mech. E. Cloth; 6 × 9 ins.; pp. 340; tables and 75 illustrations. London: P. S. King & Son; New York: John Wiley & Sons. $3.50.

This book attempts to show, as far as possible, "how refuse is being dealt with all over the world." Considering the difficulties involved the author seems to have done remarkably well, with the exception that his strong bias in favor of cremation, combined with his reliance upon information obtained at second hand, has resulted in a very inadequate presentation of the many large garbage reduction works in the United States. To this we shall revert when dealing with the section of the book relating to America.

The scope of the book is wider than might be thought from the words quoted above. It is more than a description of practice. It discusses principles and criticises methods. In fact, its scope leaves little to be asked for in a treatise on refuse disposal. Such faults as we have noted are due to either a scanty treatment of some divisions of the subject, misinformation, lack of information, and the bias already mentioned.

On the whole the book appears to be a decided advance on its only rival, in the English language, which is Maxwell's "Removal and Disposal of Town Refuse," reviewed in our issue of Jan. 5, 1899. Maxwell gave more space to descriptions of the various types of furnaces, and also to particular installations, but he confined himself almost wholly to Great Britain and quite ignored disposal by reduction.

The present volume opens with an interesting chapter on "The Evolution of the Refuse Destructor" in England, which has been going on for some forty years. The unsatisfactory low-temperature furnaces were improved by the addition of the Jones' fume cremator to the base of the chimney stack. Then came higher temperatures and the installation of boilers for the utilization of heat. The latter are rapidly becoming a feature of all refuse destructors in Great Britain.

There are separate chapters on "Refuse Tipping" and "Refuse Sorting and Utilization," the latter word here meaning the sale of coal, fertilizing materials, paper, and the like, as recovered by sorting. Both promiscuous sorting and tipping are condemned by the author as unsanitary, and the latter is denounced in strong terms as being dangerous and degrading to the men and women who perform the work.

The chapter on "The Value of Town's Refuse for Steam Raising" is only eight pages in length, but the results of a number of tests are included in the descriptions of various installations given elsewhere in the book. The first four pages of this chapter are composed of rather general discussion. One interesting point is that where coal is very cheap the people are wasteful of it, so the city wastes have a higher fuel value than in other sections. Of the four remaining pages of the chapter three are devoted to "various coals" and but one to "refuse." This one page is made up of three tables, all taken from other writers. The first table gives the average composition, and the second the average heating power of ashbin refuse. The third table gives the "average evaporative power of town's refuse obtained in practice." The first two tables we have combined in one, as follows:

	Average composition by weight (Hutton).	Average heat units per lb. combustible (Dawson). Dry.	Containing average % moisture.
Coal	0.7	14,000	9,334
Coke	0.3	12,000	8,000
Bones and offal	0.6	8,000	5,334
Breeze and cinder	50.0	6,000	4,000
Rags	0.4	5,000	3,334
Paper, straw, fibrous material and vegetable refuse	13.0	3,800	2,534
Ash	12.0	....	....
Dust and dirt	20.0	....	....
Bottles, metals, etc	3.0	....	....

The third table places the water evaporated from and at 212° F. per 1 lb. of refuse fuel at 2 lbs. for the best screened ashpit refuse, 1.50 lbs. for the average screened, 1.25 lbs. for the best unscreened, 1 lb. for average unscreened and seldom more than 0.75 lb. for unscreened wastes of inferior quality. This table is credited to Hutton, but there is no indication of what is meant by results "obtained in practice." Most of the detailed tests reported in this book extended through a day or considerably less. So far as we are aware, no records extending over several months, to say nothing of a year or more, are available. Anything like satisfactory figures of the unit cost of operating combined refuse destructors and power plants are even more scarce than the results of evaporation tests.

In a brief chapter on "Slow versus Rapid Combustion," the author favors the latter, and consequently forced drafts. The three chapters on steam boilers, boiler setting and the like, and chimneys and drafts appear to contain quite a large amount of useful information.

Fourteen chapters are devoted to a review of refuse disposal in all the chief countries of the world. For England, Wales, Scotland and Ireland all communities of 2,000 and upwards, with their respective populations, are listed, and more or less information is given about the various destructors in use. Including 18 London vestries or parishes, about 130 communities in Great Britan and Ireland are provided with destructors. Less than half the London vestries, however, and these not the most important, are so provided, but of 32 so-called Great Towns in England and Wales, 23 burn some part of their wastes. These places are all county boroughs of 100,000 population* or upwards. Of 30 other county boroughs, with populations, so far as given, from 23,000 to 73,000, 14 have furnaces and 16 have not. Many small places in England have furnaces, but more than 800 places in England and Wales with populations of 2,000 or more had no destructors when the list was compiled. In Scotland, likewise, three out of 148, and in Ireland, three out of 100 communities were "tipping their refuse," on the supposition that it was collected in all of them. On the continent of Europe improved means of garbage disposal are less common than in Great Britain, while in the other countries of the world, outside of North America, comparatively little has been done. A few distant foreign cities have adopted some of the best types of English furnaces.

Next to Great Britain no other country in the world has attempted so much in the garbage disposal line as the United States, either in the number and size of the cities that have taken up the work, or in the variety of methods employed. The variety of methods and, we regret to confess, the general unsatisfactoriness of most of them, Mr. Goodrich brings out, but he fails to make clear the number and size of the American cities in which are to be found reduction plants. Such plants are not only given scant attention, but are rather sweepingly condemned as unsatisfactory. Even if the author was wholly right in his views of the American methods of recovering grease and fertilizing material from garbage, the extent and cost of the plants employed, the mechanical ingenuity displayed in their design and construction, and the number of large cities served by this process of garbage disposal would seem to warrant more attention than he has given to the subject. This is particularly true of a book whose very title claims for it the distinction of considering refuse disposal from an economic standpoint, for whether or not garbage reduction is an economic solution of the problem that is one of the chief claims made for the process.

The accompanying table shows that of the 19 cities of the United States having populations of more than 200,000 only one depended upon cremation during the year 1900, while nine depended on reduction plants and nine others dumped their garbage on land, or in water. The one city in the garbage cremation column had a population of 343,000 in 1900, while the three in the reduction column had an aggregate population of 7,535,000. The cities that had not yet advanced beyond dumping, or like New Orleans and Milwaukee, had returned to it (temporarily, in the latter case), had an aggregate population of 3,919,000. The nine cities named are not the only ones having reduction plants, and as one runs down the scale of population this method of disposal more and more rapidly gives way to cremation. The point we wish to make clear is that, good or bad, one of the most notable things concerning garbage disposal in the United States is the adoption, by the largest cities, of reduction, rather than cremation. Or, perhaps, we should say the adoption by contractors, since neither the crematory at San Francisco nor a single one of the nine reduction works, are owned or operated by a city.

Status of Garbage Disposal During 1900 in the 19 Cities of the United States with Populations of Over 200,000.*

	Population in 1900— Cremation.	Reduction.	Dumping
New York	.....	3,437,000†	.....
Chicago	.....	.....	1,699,000
Philadelphia	.....	1,294,000	.....
St. Louis	.....	575,000	.....
Boston	.....	561,000	.....
Baltimore	.....	.....	500,000
Cleveland	.....	382,000	.....
Buffalo	.....	352,000	.....
San Francisco	343,000	.....	.....
Cincinnati	.....	326,000	.....
Pittsburg	.....	322,000	.....
New Orleans	.....	.....	287,104
Detroit	.....	286,000	.....
Milwaukee	.....	.....	285,000
Washington	.....	.....	279,000
Newark	.....	.....	246,070
Jersey City	.....	.....	206,000
Louisville	.....	.....	205,000
Minneapolis	.....	.....	203,000
Total	343,000	7,535,000	3,919,000

*Based on the conditions prevailing for the major portion of the year 1900, since even had there been an attempt to cover the subject in the book it would hardly be brought down to a later date. During the latter part of 1900, and the first half of 1901, the following changes from the showings of the table took place: Chicago installed a small garbage furnace in connection with one of its electric lighting stations. Baltimore let a contract for garbage disposal; the understanding is that reduction will be employed. Buffalo's reduction plant was burned down but a new one is said to be about ready for use. Milwaukee let a contract for garbage furnaces. Washington let a contract for disposal by reduction. Louisville and Minneapolis installed furnaces, but early in 1901 only a part of the construction at Louisville had been completed.

†A small portion of the population is served by garbage crematories scattered about in the outskirts of the city, but probably a greater aggregate population has its garbage disposed of by dumping.

We respond to a request in the preface by pointing out some of the errors and misleading statements in the American chapter. On one page the Brown crematory is spoken of as in use at Wilmington, Del., and on another it is said that the Dixon has been adopted there. The Dixon superseded the Brown. The Rider furnaces used for a number of years at both Pittsburg and Allegheny have given place to reduction plants, and the author himself mentions a reduction plant at Pittsburg. The Dixon furnace at Atlanta, Ga., was superseded nearly two years ago by a Lester furnace, a type not mentioned in the book; but there is only this one in use. The reduction works at Cincinnati are not closed and those at Philadelphia now serve the whole city.

Such errors as locating Dayton and "Youngtown" in Oregon, some 2,000 miles from their real site in Ohio, and placing West Point, N. Y., in New Jersey, and Lafayette, Ind., in Mississippi, might easily have been avoided.

The section specifically devoted to reduction processes occupies about six pages. It opens with the statement that such "plants have failed for many reasons." The first reason to be given is that "garbage is the only portion of a city's waste with which it is possible for such a plant to deal," and therefore wastes must be sorted, either by householders, or at the reduction works. If the latter practice is followed he declares that the resulting nuisance is intolerable. The author then says that the reduction system involves "much costly and complicated machinery," which must be "in duplicate in case of breakdown," thus demanding heavy capital outlay. This is quite true, but the advocates of reduction claim that the products recovered compensate for the outlay involved, a point which Mr. Goodrich does not discuss. His next argument is unique, namely, "the danger of a strike in the event of an epidemic." Why a strike in reduction works more than in a cremation plant, and, more pertinent yet, why a strike in either? After the foregoing array of "reasons" for the failure of reduction works the author says:

It will thus be seen that such a method cannot seriously commend itself to sanitarians; it is weak all round, and unsatisfactory.

A little further on it is stated that "the principal reduction plants in America have been installed at St. Louis and Philadelphia, whereas the one at New York is the largest garbage disposal works of any kind in the world. In another place a quotation from Mr. A. H. Andrews, of Atlanta, Ga., is inserted to the effect that less than 20 garbage reduction plants have been built in America.

*All these populations, we suppose, are from the British census of 1891, since the book was published prior to the 1901 census.

which has already been used on contract work with success in different kinds of soil.

The machine consists of a frame built up mainly of steel I-beams and mounted on four broad-tired wheels. Over the front axle is a shaft to which is pivoted a frame about 20 ft. long composed of two steel channels connected by cross pieces. The shaft at the head of the machine, to which this frame is pivoted, and another shaft at the outer end of the frame are each fitted with two hexagonal sprocket wheels carrying a pair of endless link-belt chains, built up of steel drop forged links connected by cross bars and flat blades or scrapers. Each cross bar is fitted with two or three cutters of drop forged steel, the cutters on the several bars being staggered so that the entire series of cutters will cover the whole width of the excavation. Alternate bars are also fitted with side cutters or reamers for trimming the sides of the trench so as to give a clearance for the cutter frame. The blades behind the cutters form scoops to carry up the material removed by the cutters.

At the rear end of the machine are two vertical sliding bars, the lower ends of which are attached to the end of the cutter frame. The bars are fitted with racks, gearing with pinions on a transverse shaft above the rear axle. This shaft is driven by gearing and the arrangement constitutes a "crowding" device for forcing the cutter frame against the bottom of the trench, so that the greater part of the weight of the machine is carried by the breast of the cut.

The depth of the cut is regulated by raising or lowering the free end of the cutter frame. The cutters travel up along the working breast, loosening material which is carried up by the blades or scrapers. At the head of the machine this material is dumped upon two horizontal belt conveyors, at right angles to the trench, which discharge the excavated material either into wagons for removal or upon the ground alongside the trench ready for the backfilling. The machine hauls itself along by means of a wire cable anchored about 300 ft. ahead. This cable is wound upon a drum which has at one end a rachet driving wheel. The pawl of this wheel is operated by a rod from an eccentric on the main shaft of the machine, and the throw is adjustable, so as to allow of regulating the speed of advance or feed according to the depth of cut and the character of the material.

Power is derived from a 25-HP. traction engine coupled ahead of the machine. The main shaft of the engine carries a sprocket wheel connected by a link-belt driving chain with a similar sprocket wheel on the main shaft of the excavating machine. From this latter shaft a link-belt drives the shaft at the head of the cutter frame, while vertical link-belts drive the bevel gears from which the conveyors are operated. Two men are required; one to operate the traction engine, and the other to operate the excavator, stopping and starting the cutting mechanism and regulating the speed as required. Other men attend to the hauling cable, the trench sheeting and the backfilling.

Fig. 1 is a general view, showing the machine at work on a sewer contract at Glencoe, Ill. The machine itself is behind the Case traction engine. To the left of the engine pulley will be seen the link-belt transmitting power to the main shaft of the excavator. On this shaft are the large sprocket wheel for the driving chain or belt and also three smaller sprocket wheels. The small wheel at the end of the shaft carries the horizontal chain which drives the shaft at the head of the cutter frame by the large sprocket wheel shown above the conveyor. The other two wheels carry the chains for driving the conveyors. Near the end of the frame will be seen one of the inclined bars of the crowding device already described. Fig. 2 is a view of the trench, with the machine at work in front and the pipe laid ready for the backfilling.

The machines have been used at Chicago, Flossmoor, Harvey and Glencoe, Ill. At the latter place about 6,000 ft. of trench have been excavated, the width being 2 ft. and the depth from 9 to 15 ft. The material there was very hard stiff clay, which stands well, as may be seen in Fig. 2, requiring sheeting boards only at intervals of about 18 ins. The sheeting is supported by iron screw-jack trench braces. The 2-ft. trench would be too narrow for excavation by hand, but just allows room for the pipelayers to work, the pipe being kept up to within about 15 ft. of the machine. Behind the pipelaying the backfilling is done by a horse and drag scraper, with two men; the scraper working across the trench and scraping the excavated material from the ridges into the trench. In this hard material the excavator advanced about 50 ft. an hour, but in good earth, free from boulders, the progress may be as much as 100 ft. an hour. At Glencoe, 590 ft. of trench 13 to 15 ft. deep were excavated in a working day of ten hours.

Small boulders can be handled, the cutters loosening the material around them until they fall out and are carried up by the blades. For large boulders, the cutter frame can be raised and the stone removed by picks. The machine will work in any place where there are not too many rocks and large stones which the machine cannot handle. It will cut trenches 24 to 48 ins. wide, and as deep as 20 ft.

These trench excavating machines were designed by the F. C. Austin Mfg. Co., of Harvey, Ill., and are built by that company for the Municipal Engineering & Contracting Co., of Harvey, Ill., which has acquired the sole right for their use. The latter company, therefore, makes a specialty of taking sub-contracts for the trench excavation on sewer or water-works contracts and similar work.

FIG. 1. TRENCH EXCAVATING MACHINE AT GLENCOE, ILL.
Municipal Engineering & Contracting Co., Harvey, Ill., Owners.

FIG. 2. REAR VIEW OF TRENCH AND EXCAVATOR.
F. C. Austin Mfg. Co., Harvey, Ill., Builders.

AGRICULTURAL MACHINERY IN THE CANADIAN PAVILION AT THE GLASGOW EXHIBITION.*

By G. Harwood Frost, B. A. Sc.†

In the Canadian Pavilion at the Glasgow International Exhibition, Canadian implements are represented by the products of six factories—the Massey-Harris Co., Toronto; the Frost & Wood Co., Smith's Falls; the Noxon Co., Ingersoll; David Maxwell & Sons, St. Mary's, all of which manufacture a large variety of implements, and the Verity Plow Co., and the Cockshutt Plow Co., both of Brantford, which are devoted exclusively to the production of plows.

The earliest implements used by the settlers in Canada were imported from Great Britain, but as the almost illimitable area of arable land in Canada became opened up to settlement the demand for implements soon induced thier manufacture at home. The rapid development of the West rewarded these early manufacturers with success, and the capacity of their factories was constantly

*From a paper read before the International Engineering Congress at Glasgow.
†Smith's Falls, Ontario, Canada.

ft. above the derrick and blew out 6 tons of 4-in. pipe, together with rock, etc. The first flow was estimated at 250 barrels per day, but this rapidly increased until experienced judges placed the outflow at 75,000 barrels per day. It flowed at this rate for nine days, and was capped on Jan. 19. (See Eng. News, Aug. 1, 1901.) Other "gushers" followed this first well; and by June 30, 1901, 15 oil wells were spouting in this district.

The chemical composition of the crude Beaumont petroleum is given as 86.8 carbon, 13.2 hydrogen, no appreciable oxygen, and 0.920 specific gravity, compared with water classed as 1,000. Compared with other crude oils, in the same sequence, we have the heavy oil of West Virginia, classed at 83.5, 13.3, 3.2 and 0.873 specific gravity; heavy oil of Pennsylvania, 84.9, 13.7, 1.04 and 0.886; heavy oil from Baku, 86.6, 12.3, 1.1 and 0.938; oil from Java, 87.1, 12.0, 0.9, 0.923 specific gravity.

In reference to the reported existence of an oil pond in the Gulf of Mexico, just off the coast of Jefferson county, three separate expeditions sent out to investigate report adversely upon the existence of any oil at this place, other than such as manifestly has made its way from the surface overflow at Beaumont. There may be, as reported, a calm spot in the sea at this point, but the writer does not believe that any such phenomenon is due to the outflow from an underground source of oil. He thinks the true explanation is that the bottom of the sea is here a thick black mud, in which are imbedded various animal and vegetable remains. Under incipient decomposition substances of a more or less oily nature are formed, and under wave action these rise to the surface and affect that surface in a manner comparable with the presence of oil. The soundings on this "oil pond" vary from 4 to 16 ft., while outside this shallow area the depth increases to 20 to 25 ft., and the 5-fathom curve lies about one mile to the south. This "oil-pond" is thus a sort of terrace rising above the sea bottom and easily affected by the waves.

In Texas the stores of lignite, sulphur and oil are found in the Tertiary and the formations immediately preceding it, and the greater weight of opinion now inclines to the view that petroleum is derived from the decomposition of both animal and vegetable remains. From this point of view the so-called "oil-pond" referred to may possibly be an oil-bearing deposit in process of formation. The drill shows that while the vegetable and animal remains in the Tertiary give rise to local oil deposits, where the conditions are most favorable, these deposits are not of regular extent, and even in the Beaumont field there are dry holes—or no oil. Just what has caused this segregation no one is yet prepared to say. If we may connect the action of diatoms with the formation of oil deposits we may go far towards settling the origin of much of the oil on the Texan coastal plain.

The association of sulphur and petroleum, especially throughout the area covered by the Tertiary in Texas, affords another indication of the diatomoceous origin of these two substances, says Prof. Phillips. But it must be understood that in this region the presence of sulphur or sulphur compounds is not an unfailing indication of oil in commercial quantities. Many wells have been bored in what is considered the oil area without meeting any oil indications, though sulphur compounds were found. While the sulphur appears to go with the oil, there are many localities where the oil does not seem to go with the sulphur. So far as now known, the oils of the Texan coastal plain are sulphur oils, and the rock with which the Beaumont oil is associated and which forms the capping over the oil, contains 1.80% of total sulphur and 1.58% of sulphur, free and in organic compounds. The area covered by the coastal plain seems to have been formed under conditions that allowed the formation of beds of lignite, together with pyrite and other sulphur compounds, and petroleum. Whether these have had a common origin or whether the original substances have suffered radical changes in the course of time only further research can determine with positiveness.

The limestone forming the cap-rock of the Beaumont oil deposits shows the following under analysis:

	Per cent.
Silica	0.40
Oxide of aluminum. } Oxide of iron. }	0.50
Lime	54.89
Magnesia	trace
Sulphur, free and in organic combination	1.58
Sulphur as sulphuric acid in combination	0.21
Carbonic acid	42.45

In other parts of the state the origin of sulphur deposits associated with oil may be sought in the action of volcanic gases on limestone, whereby there would result sulphur, gypsum and various hydrocarbons. Igneous rocks are found in the sections referred to, and the formation of oil and sulphur may have gone on together, and it is possible that inorganic and organic agencies were concerned in creating the same deposit.

The Carboniferous formation in Texas has an extreme length of 225 miles—from the San Saba River north and northeast to the Red River—and it is about 100 miles wide, from a point south of Weatherford, Parker county, to a point east of Abilene, in Taylor county. Within this area of about 15,000 sq. miles both oil and natural gas have been found in many places, but no commercial use is yet made of these deposits. Asphalt is found in Montague and Cooke counties, but the field is little explored. Near St. Jo, in the first county, there are extensive deposits of asphalt rock that show an analysis 2.1 to 10.6% in total bitumen.

In the Corsicana oil field of Texas oil was discovered prior to 1894 at a depth of 1,027 ft., while boring for water; and in 1896, 47 wells yielded 65,975 barrels of oil. The gas pressure in some of the later wells in this region has reached 200 lbs. per sq. in.; and this gas area may be quite extensive, as it is found 75 miles away from the first outflow. The present Corsicana oil field is about 6½ miles long by 2 to 3 miles wide, though there are several dry wells in this area.

The report of Prof. Phillips enters fully into the description of the various other oil producing districts of Texas, gives full analyses of the several oils and discusses the production and the possible uses of this fuel oil; but for this detail we must refer the reader to the report itself. Applications for copies should be addressed to Prof. Phillips, at Austin.

A REGENERATIVE ACCUMULATOR AND ITS APPLICATION FOR USING EXHAUST STEAM.*

By M. A. Rateau.†

The new apparatus referred to in this paper is intended to allow, in a turbine or any other motor, the use of the exhaust steam from machines having intermittent action, such as winding engines or the reversible engines of rolling mills. Engines with intermittent action are well known to be defective in respect of the satisfactory use of the steam, caused by condensation within the cylinders. This inconvenience has no doubt been to a small extent remedied by compounding and also by condensing; but the advantage gained is much less than can be obtained by using the steam at about atmospheric pressure in a turbine provided with a condenser.

The Hon. C. A. Parsons has already urged the use of turbines with low steam pressure, attached to continuously-running steam engines. For instance, if we take a winding engine using 45 kg. (99 lbs.) of steam per B. HP., which is about the maximum for non-compound engines without condensation; these 45 kg. of steam are sufficient to give, in a steam turbine, coupled to a dynamo, at least 2 electric HP. By the application in this case of the regenerative accumulator system, 2 HP. is added to the 1 HP. of the winding engine.

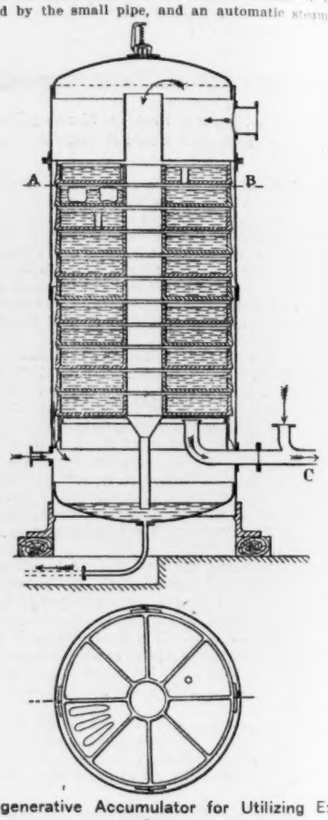
The difficulty which this apparatus solves is the following: The turbine requires to be supplied with a continuous flow of steam, whereas the engine working intermittently delivers it at more or less regular intervals of one or two minutes. A reservoir is therefore required between the two engines. An ordinary reservoir would have excessive dimensions, whilst with the apparatus about to be described this excessive size is avoided, and the cost of erection is relatively small.

This apparatus, which may be called a "regenerative steam accumulator," serves the purpose of a reservoir. The solid and liquid materials, which it contains, form a storage in which the steam gathers and condenses when arriving in excess, and subsequently revaporises during the period when the main engine slackens or stops. The variations in temperature necessitated by the condensation and re-evaporation of steam correspond to the small fluctuations of pressure in the accumulator. The pressure rises while the apparatus is filling, and falls while it is being emptied. The amplitude of these temperature and pressure oscillations is not great, 3° to 5° C. and 0.10 to 0.15 kg. per sq. cm. (1.4 to 2.1 lbs. per sq. in.). This variation can be limited to any desired range by designing the apparatus sufficiently large in accordance with the periods of running and standing of the main engine.

Calling the variation of temperature t (which is in practice 3° to 5° C.), the weight of materials providing the storage of heat P, and the mean temperature of these materials G, the quantity of heat absorbed by the accumulator and restored by it at each period is P G t calories; and 1 lb. of condensed vapor, then vaporized corresponds to this number of calories, equal to about $\frac{P G t}{L}$, L being the latent heat of the steam.

The apparatus consists, as may be seen from the illustration, of cast-iron annular basins placed one above the other, inside a cylindrical shell. The steam, which enters the vessel by the pipe near the top, reaches the basins by the central channel. The portion which is not condensed, as well as that which is re-evaporated, descends along the lateral partitions of the vessel, and reaches the pipe C leading to the low-pressure machine.

The water carried away by the steam separates out in the upper chamber and falls, first through holes in the top plate, thence from basin to basin by the passages in the overflow to the bottom of the vessel, whence it is discharged by the small pipe, and an automatic steam trap.



A Regenerative Accumulator for Utilizing Exhaust Steam.

The basins are thus always covered with water. The apparatus is completed with a safety valve and an automatic steam valve for assisting the turbine by steam direct from the boilers.

By means of this accumulator it is possible to obtain, in an ordinary-sized winding-engine plant, an additional motive power of about 500 HP., with no expense but the cost of installing the turbine and accumulator, which is not great. An application of 250 HP. is now in course of erection at the Bruay Mines in the North of France, and will be working in a few months.

*A paper read before the International Engineering Congress at Glasgow.
†Paris, France.

A NEW TRENCH EXCAVATING MACHINE.

Among the recent developments in excavating machinery is its application to sewer trenches, the excavation of which by hand often requires the removal of much more material than is actually needed for the trench, owing to the necessity of having the trench wide enough for the men to handle their tools. In deep trenches, also, the work by hand labor is often increased by the necessity of working in stages, the material being handled two or three times before it reaches the surface. The accompanying cuts represent a new trench excavating machine which does the work cheaper and quicker than by hand, and

parts. In all the Canadian mowers and binders shown in the exhibit roller and ball bearings are used. The proper application of these bearings has been a problem that has taken years of experimenting to solve. At first they were used on the binder only for the bearings of the main driving wheel, then they were put in a small grain wheel and the main gear shaft, and latterly they have been applied to the crank shaft and to the bearings of the apron rollers. After a certain amount of experience it has been found that on the crank shaft they can be applied only at the gear end. At the connecting rod end the constant jarring caused by the rapid vibratory motion of the knife renders them impracticable, as the strongest

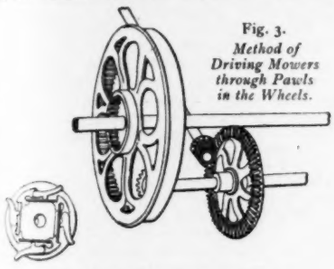


Fig. 3. *Method of Driving Mowers through Pawls in the Wheels.*

Two leading methods of attaching the Connecting-rod to the Knife.

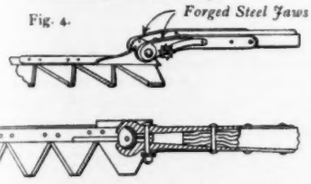


Fig. 4. *Forged Steel Jaws*

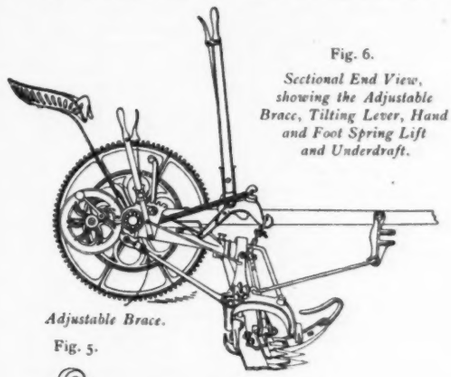
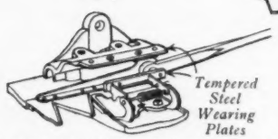


Fig. 6. *Sectional End View, showing the Adjustable Brace, Tilting Lever, Hand and Foot Spring Lift and Underdraft.*

Adjustable Brace.

Fig. 5.



Tempered Steel Wearing Plates

FIGS. 3 TO 6. DETAILS OF CANADIAN MOWING MACHINE.

cage is soon shaken to pieces, so at this place a renewable brass bushing is used. Their use on the apron rollers has not proved a success, as the extremely small cages and rollers necessitated soon become clogged with oil and dust, so in a majority of the machines self-alineing metal bearings are used. The roller bearings are made of hardened steel rollers of ⅜ to ⅝-in. diameter, so set in a malleable iron cage that they are free to turn with little or no friction on the ends of the cage, and at the same time will not come out of place when the cage is removed for cleaning.

On the mower, rollers are used for the bearings of the drive wheels and the intermediate gearing, and renewable brass bushings on the cross shaft. Ball bearings are used to take up the end thrust on shafts due to the bevel gear. On some of the machines provision is also made for taking up the wear in the bevel wheels, thus keeping them always in perfect mesh, and allowing the machine to work as evenly after years of use as when new.

The use of steel for the framework and platform of the binder is now universal. Formerly the platform was made of wood, some of the braces of weed and some of iron giving the machine a heavy and cumbersome appearance. With the reduced price of steel caused by the erection of a number of steel works in Canada, its use has been largely extended by all manufacturers.

STANDARDS OF MEASUREMENTS IN FIELD ENGINEERING.*

By Benjamin Franklin, C. E.

In this discussion the subject naturally divides itself into two heads: first, the differences in standard; second, the mechanical inaccuracies.

The extent of variation referred to in the first of these divisions is a surprise to those members of the profession who are not familiar with municipal work. For instance, the United States foot is not recognized as a standard in the work in any of the survey districts of Philadelphia. What is known as the Philadelphia standard is an excess of 0.25 ft. for each 100 ft. in United States measure. But the Philadelphia standard itself, however, is not constant. In one district the allowance is 0.08 in. per 100 ft.; in another, 0.13 ft.; in another, 0.17 ft.; in others, 0.25 ft. and 0.27 ft. Sometimes two or more variations occur in a single district, and in one instance which came under our notice, an architect calling for a plan, United States standard, found that each side of a quadrangular lot had a standard of its own, none of which corresponded to any of the above figures.

In the further pursuance of this investigation, the writer some time ago entered into correspondence with the engineers of the principal cities of the United States. As far as could be ascertained, with the exception of Boston and New York, Philadelphia practice is followed nowhere else in this country. In Boston the variation ranges from 0.014 to 0.02 per 100 ft. In New York city and Brooklyn the conditions are similar to those prevailing here, although probably not to the same extent. In these places there are two recognized standards: the old Dutch measure, which is 0.1 ft. longer in each 100 ft.; and one that was introduced later, in which the excess is 0.017 ft. for the same distance. As, however, it is the custom there to establish a separate standard for each block from the old monuments found on the ground, it is, of course, evident that the recognized local standards themselves are subject to considerable variation.

It is unnecessary to dwell long on the confusion and frequent embarrassments which an unscientific system of this character entails. In any large steam railroad operation within the city's limits, where railroad engineers who use United States standard only have to work in conjunction with the district surveyors, using their several standards, there must certainly be a conflict of methods and a liability to error before final results can be reached.

Again, it is easy to conceive instances in which bridges and buildings might be designed by parties unfamiliar with local conditions; and costly and irritating delays occur through the furnishing of plans whose dimensions are in city standard.

It is in many cases difficult to trace the causes for such a variety of standards. One may be found in the desire of the early surveyor to give "good measure." Even the modern surveyor is not entirely lacking in this generous impulse, for we have found a tract, easily seen from Penn's Tower, laid out within the last 20 years, where 1 in. in every 50 ft. was allowed for this purpose.

Moreover, there is no question but that the measures used by the colonies before the Revolution were almost entirely those of England, and they continued so, without being specially legalized, for some years after that period. The old British standards about the year 1740 were as follows: The standard English perch was 5½ yds.; the standard woodland perch was 6 yds.; the church land measure perch was 7 yds.; the forest measure perch was 8 yds.; the plantation perch was 7 yds.; the Scotch perch was 6 1-6 yds. It is, of course, fair to presume that in early surveys of this country some one, or even all, of these standards were used.

We believe, however, that many of the original surveys, especially those of towns, were made with the English standard perch of 5½ yds., with an allowance for broken and forest land. This is supported by the statements of old surveyors, who tell us that the chains of our forefathers were made 1 in. longer for each two rods of length.

In the instructions given in 1881 to United States deputy surveyors, the designated length of chain for use in township and subdivision surveys is 66.06 ft. The object in adding the 0.06 is to correct for "sag" with a pull of 20 lbs. These chains are tested with a fixed standard each working day.

In leaving this branch of the subject, the question naturally suggests itself, is there no remedy for a practice which is certainly unscientific and possibly illegal?

In the consideration of the second division of the subject, the discussion relates only to accuracy in measurement. It has seemed to the writer that two points ought to be borne in mind by every engineer in his practice: The first is to know when to be accurate; the second is, regardless of the degree of accuracy, to always check results. The care, nicety, and refinement absolutely essential in measuring base-lines for primary triangulation or city block distances are unnecessary in many kinds of field engineering; but while the relative accuracy of the work may vary, the need for checking is constant.

There are four well-known appliances used in making measurements: First, the rod; second, the chain; third, the steel tape; fourth, the stadia wires. The rod is so rarely used now in ordinary measurement that we will eliminate it entirely from this discussion.

It is said that the first chain made in accordance with an act of Congress was manufactured by David Rittenhouse, of Philadelphia, in 1797. It was of double links, and was 33 ft. long. The old chain of 66 ft. and the later chain of 100 ft. have until recently been used almost entirely in making land and railroad surveys; but they are now being generally discarded, and another generation may know them only by tradition. It is necessary to enumerate a few only of their defects. Thus, in a 100-ft. chain, there are 600 points of contact; according to Professor Johnson, 800. Again, it is estimated that, for a chain 100 ft. long, in order to overcome the "sag" a pull of 60 lbs. is necessary. When we add to these not only the errors characteristic of every measuring instrument, but also those peculiar to the chain itself—such as the flattening, opening, stretching, kinking, and bending of rings—we can readily conceive what basis the old surveyors had for their alleged practice of shortening a chain every second or third day when in continuous use. Yet as late as 1880 Engineering News, in an article from Professor Jackson, states that steel tapes are only slightly more accurate than common land chains.

In the discussion of steel tapes we reach a very important division of this topic. Under this head we include not only the graduated tape of the Chesterman type, but also the narrow band or flat wires. Chesterman invented his tape about 1842, but there is no record of its use in this country earlier than 1860. At the present time both the tape and the wire are employed for any variety of measurement, and when skilfully handled, afford results that are wonderfully accurate and inexpensive.

For ordinary practice 100 ft. is the accepted length of tape. Better results in good country, and for accurate base-line work especially, have been obtained with a tape

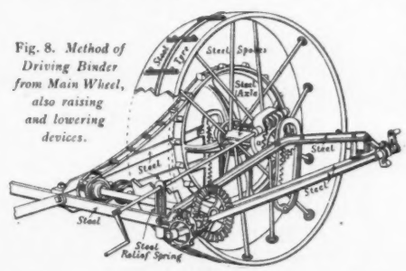


Fig. 8. *Method of Driving Binder from Main Wheel, also raising and lowering devices.*

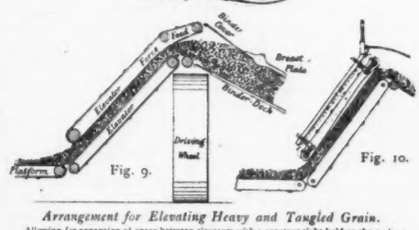


Fig. 9.

Fig. 10.

Arrangement for Elevating Heavy and Tangled Grain.

Allowing for expansion of space between elevators with a constant tight hold on the grain.

Figs. 8 to 10. Details of Self-Binding Harvester.

Fig. 12. Frost & Wood.

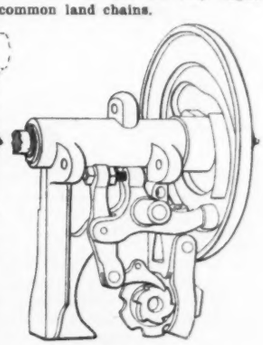


Fig. 14. Maxwell.

Fig. 13. Frost & Wood.

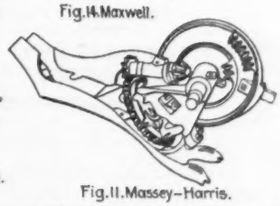


Fig. 11. Massey-Harris.

Figs. 10 to 14. Details of Knotting Mechanism.

*From a paper read before the Engineers' Club of Philadelphia.

increased, until to-day Canada is the largest producing British colony and, next to the United States, the largest producer of farming machinery in the world.

For different purposes, seed is sown in different ways—broadcast, and in rows, or drills. Machines for both methods are shown—the broadcast seeder by the Massey-Harris Co. and the drill by the Noxon Co. In the regular broadcast seeders the tubes are dispensed with altogether, the seed falling from the box, and spring cultivator teeth are attached which throw the covering over it. The feed-wheel which carries the seed from the box to the tubes consists of a solid cut-away cylinder of about 3 ins. in length, Fig. 1. This is turned by a gearing driven by the road wheels, so when the machine is at rest the feed is closed; it is also closed when the hoes or shoes are lifted from the ground, or there is a motion of backing the machine. On the rear of the seed box there is an indicator showing how much seed of different kinds should be sown to the acre, grain seed being given in pecks and grass seed in pounds, Fig. 2. By moving the pointer on this indicator to the figure showing the quantity it is desired to sow to the acre, the feed-wheel is shifted, enlarging or diminishing the size of the opening in the measuring channel to allow just the amount desired to pass through. Besides this there is a dial which registers the number of acres sown. The hoes are held in position by springs which allow them to pass over obstructions freely and quickly return to their working positions. They are locked securely to the frame by clamps, without the use of bolts or pins, so that they may be easily removed and replaced by cultivator teeth. The depth at which they deposit the seed and the angle at which they cut the ground is regulated in some by spring pressure, in others by a mechanism similar to the reversing link of a locomotive; and they may be lifted out of the ground either all together by a lever or independently by chains. Another lever is provided for shifting the hoes to a double line, or zigzag position, to permit clods to pass between when working on rough, lumpy ground that has not been sufficiently broken up by the harrow.

Both mowers and binders are exhibited by the Massey-Harris Co., the Frost & Wood Co., the Noxon Co. and David Maxwell & Sons. While the principles of operation and the results obtained are the same in all, the mechanical methods of obtaining this result and the devices by which the different machines meet the varying conditions imposed upon them are different, and each firm claims superior advantages for its own construction, which it is not the purpose of this paper to discuss.

On the mower, Figs. 3-6, a solid and heavy tubular cast-iron frame is used, as this secures a more perfect and permanent alinement of the running gear and shafting than a steel frame, which must be built up of several pieces bolted together. The wheels are of cast-iron, 31 to 34 ins. high, 3½ to 4 ins. wide, and are provided with horizontal and vertical lugs on the rims to ensure good driving contact with the ground. The wheels communicate their forward motion to the shaft and the main gear-wheel through a rachet and spring pawls on the inside of the hubs of both wheels, Fig. 3. From the main gear-wheel the motion is communicated to the cross-shaft by various arrangements of spur and bevel wheels and pinions, giving a rapid motion to the crank, and thence to the knife through the connecting rod. The connecting rod is long, and is in some machines made of wood, the variety used being well seasoned second-growth hickory, and in others it is of wrought-iron or steel. It is attached to the knife head and to the crank either by a ball and socket joint, Fig. 4, or by a hook and eye, Fig. 5. The speed given is in a ratio of from 55 to 62 vibrations of the knife to one revolution of the drive wheels. A lower speed than this would not cut rapidly enough in heavy grass to prevent some of it blocking the action of the machine, and a higher speed would overheat the bearings. The cutting apparatus, consisting of the heavy steel cutter bar, the fingers or guards, and the sectional knife, is attached to a hinged portion of the main frame, called the hanger, by large bearings, and is supported at each end by a shoe with either wheels or steel runners. It is made of different lengths to cut a swath of from 3½ to 6 ft. wide, and the width of tread between the drive wheels is proportionately wide—from 3½ to 5 ft.—to give the machine stability. The knife is held tightly against the guard plates by several clips, to make a close shear cut and to prevent short and soft grass from getting between the knife and the bar.

The hay loader, Fig. 7, is a comparatively recent machine, but its use is being greatly extended every year. Its advantages are many, the principal being, perhaps, that by its use hay is often secured when ready for the stack that might otherwise be ruined by the weather. When the hay has been turned and thoroughly dried it must be collected without loss of time, and the farmer often works far into the night rather than take the chances of losing his crop before morning. Further, the loading of the hay on the wagon is the most laborious part of haymaking. With the loader it is possible for three men to place a ton of hay on a wagon in five minutes, while it would require the same men fully 15 minutes to do the work by hand. The machine is attached to the rear of the wagon and operated by the same team that draws the load, adding but slightly to the draft. The driving power comes from the wheels through a rachet and pawl in the hubs, which may be thrown on and off at will. These drive a cylindrical cage revolving on the axle and carrying six rows of curved teeth, which pick up the hay and deposit it on an elevating screen, whose driving roller is the revolving cylinder. It is then carried to the top of the loader, whence it falls on the wagon, where it is put in position by hand labor. The angle of elevation is automatically adjusted as the height of the load on the wagon increases. An upright frame supports several long wood slats, which rest on the ascending hay to prevent its being carried away by wind or falling over the sides.

The binder, Figs. 8, 9, 10, is essentially a place-changing machine; it cuts the grain, binds it in compact sheaves and delivers the sheaves, but it in no way alters the form or condition of the grain itself. To do this there are six distinct operations, namely, reeling, cutting, elevating, packing, tying and discharging. The mechanism for each of the first four operations forms a complete machine in itself, which can be worked independently, and those in which adjustment is necessary for varying conditions are separately controlled by the operator, while the last two operations are worked together. The reel holds the grain against the knife until it is cut, then lays it on the moving platform canvas, which carries it to the foot of the elevators. Here it is carried upward between two canvases to the top and on to the slanting binder deck, under which the packers work. It is then packed tightly against the binding cord until the required size of bundle is obtained, when a trip is pressed releasing a catch, which, in turn, throws the tying mechanism into gear. The needle arm rises through the deck, carrying the twine which completes the circle of the sheaf, a quick knot is tied, the twine cut, the needle quickly returns to its position below the deck, and the bundle is discharged on the ground or on a carrier, at the will of the operator.

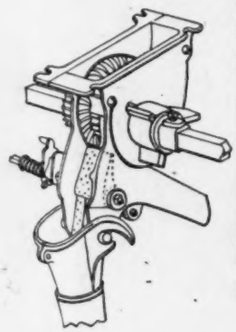


Fig. 1. Hoe Drill: Detail of Feed from Seed-box into the Tubes.

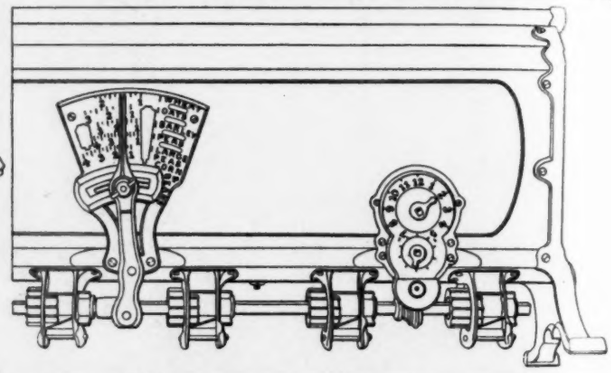


FIG. 2. ARRANGEMENT FOR REGULATING THE FLOW OF SEED, AND DIAL FOR INDICATING NUMBER OF ACRES SOWN.

The entire mechanism is driven from a high and broad-rimmed steel wheel, whose motion is communicated to the main gear shaft through a large sprocket wheel and a powerful endless chain, Fig. 8. On this shaft is located the arrangement for throwing the machine in and out of gear, controlled by a lever within convenient reach of the driver when on his seat. From the main gear shaft the motion is communicated throughout the machine by means of chain and spur-wheel gearing. The main weight of the machine is supported by the driving wheel, and the lesser weight by a steel grain wheel at the outer end of the platform. At each end of the platform there is a divider extending about 2 ft. in front of the knife. The outside divider separates the grain to be cut from the standing grain, supports it above the grain wheel, and lays it evenly on the platform. It is set at a slight outward angle to gather in a sufficient quantity beyond the end of the platform to provide a clear track for the grain wheel.

The crank shaft is driven directly from the main gear shaft by a bevel wheel and pinion. This drives the knife through a wooden connecting rod, as on the mower. At the rear end of the crank shaft is the sprocket wheel for driving the long main chain, which passes over several wheels, driving directly the platform canvas, the lower elevator canvas and the packers, also a shaft or roller which drives the upper elevator canvas through a chain or wheel gearing at the front. This elevator must be driven from the front, as it is narrower than the lower, to allow the heads of long grain to pass up clear of the canvases. The lower elevator is driven from its top roller, and this in turn drives, through two or three pinions, a free roller, inserted in the space between the top of the elevators and the binder deck, to carry the grain across this space without danger of its falling through on to the main wheel. Each canvas is driven from one large roller, the other rollers being smaller and free running. The rollers are of wood, with steel spindles inserted at the ends. They are pinned through in two or three places in different directions to avoid possibility of splitting, and they revolve in close-fitting movable collars, which prevent grain becoming twisted about the ends and blocking the action of the machine. The canvas aprons are provided with cross slats at intervals to hold the grain straight and prevent it from slipping.

The knotters are different in detail in all of the binders shown in Figs. 11-14, but each consists essentially of a disk keyed to the knotter shaft working the movable parts either by cams or spur teeth, a notched disk or ring to hold the twine, a gripper or hook, a knife, and a stripping hook to remove the knot from the gripper when tied. One end of the twine is always held by the holder tightly wedged between it and a short curve, and as the needle returns to its place the twine is drawn through the eye from the twine can, and against this the grain is packed. When the knotting mechanism is set in operation the curved needle-arm rises, completing the circle around the bundle and carrying the twine beyond the holder, lays it across the top of the gripper and into one of the notches on the holder. There are now two strands across the tying hook, which is given one quick revolution by the teeth on the disk, and in doing so a roller working along a cam has raised and closed the top of the gripper, tightly gripping the double strand and holding it while the twine is cut, and as the stripping hook removes the loop from the gripper the ends are held and are drawn through the loop, thus completing the knot. The delivery arms attached to the revolving shaft now discharge the bundle and the needle returns to its place. While the bundle is being bound and delivered the grain brought up by the elevators is held back by the long curved needle arm to prevent its becoming mixed with the knotter, and to permit of a clean separation of the bundles.

The bundles, or sheaves, may be delivered on to the ground or a sheaf carrier. The carrier is attached to the frame and is operated by a foot lever under control of the driver. It will carry as many as six sheaves, which are laid down at one place, thus saving much labor in gathering and stacking.

On all the binders, with the exception of the Frost & Wood, Fig. 13, the knotter driving shaft is in the center of the driving wheel. On this, however, an eccentric

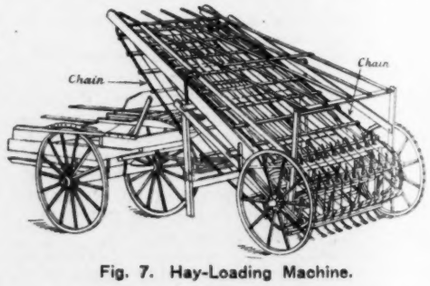


Fig. 7. Hay-Loading Machine.

lever wheel is used. When the bundle is being compressed and tied the chain draws on the long spokes, and when being delivered, it draws on the short spokes. The object of this arrangement is to obtain a greater power for compression, making a tight bundle, and for tying, thus making a more uniform draft by relieving the horses of the sudden and intermittent strains caused by the binding operation, and to give a quicker delivery of the bundle and return of the needle.

BEARINGS.—The application of roller and ball bearings to agricultural machinery has resulted in so reducing the draft that two light horses can now easily draw machines formerly requiring three or four horses, and at the same time they have materially lengthened the life of the machines by reducing friction on the wearing

300 ft. long. 500-ft. tapes are not uncommon, but, in the writer's judgment, no real economy of time results from their use.

In a very broad sense the errors which are liable to occur in any measurements may be divided into two not very clearly defined classes: The first, the cumulative, depending directly upon the tape itself, its possible constant variation from a standard, and the number of times it is used; the second, the accidental, arising from causes whose effects can not be estimated; errors from which increase as the square root of the length of the line measured.

Where accuracy is required, science and skill can eliminate the second class, and make the appropriate adjustments for the first. In the determination of absolute results by the use of steel tapes, it is necessary that the following constants be determined for each tape: First, its absolute length at a given temperature; second, its coefficient of expansion; third, its modulus of elasticity. These constants must be known in order that "sag" and temperature may be corrected, as in them are found the chief causes of inaccurate work.

Many engineers meet the question of sag in a very simple fashion, their thought being that to "pull hard and steady" is all that is required for correction. It is not an uncommon sight to see two strong, experienced chainmen, while measuring, engaged in a "tug of war" in an effort to straighten out the tape. The only strain that a suspended steel tape requires is "normal tension"; that is, a pull of sufficient strength to overcome the loss of length due to "sag." This depends upon the cross-section as well as the length of the tape between supports; and for very accurate work, the exact amount must be found for each tape by actual comparison with a standard. This "normal tension" varies from 6 to 16 lbs. for a tape 100 ft. long. The usual amount for a tape of that length, weighing 12 ounces, is a trifle less than 12 lbs. Practical men, however, recognize that while this tension is sufficient for accurate results obtained under the most favorable conditions, ordinary work requires a pull somewhat stronger in order to allow for those influences which are encountered in an average daily practice. This gives rise to what is known as a "working pull," which ought to range from 18 to 20 lbs. per 100 ft., but as actually used is higher than this, frequently 25 or 30 lbs., and on side-hill work reaching as high as 40 lbs.

In the treatment of temperature we reach the most important influence which affects the variation from standard in a steel tape. This correction is by far the most difficult to make, for the tape is extremely sensitive, and responds to changes of temperature more quickly than the average thermometer. It is affected by almost everything upon which it rests. A grassy meadow, a brick or asphalt pavement, an open road or a shaded pathway, all create changes in its length which even a delicate attached thermometer fails to indicate. Tapes in the sunlight are much warmer than the surrounding atmosphere. On a clear or windy day, or when the air and ground differ in temperature many degrees, it is impossible to obtain accurately the variations of the tape. For these reasons it has been found that still, cloudy days, or days on which there is a light drizzling rain, give very favorable results, while the utmost possible accuracy has been obtained by making measurements on quiet calm nights. Steel tapes are standardized at 62° F., which Professor Johnson thinks is too low. He recommends 80° instead, since most of the practical work is done in warm months and in good weather.

It is not necessary to dwell here upon the methods for determining temperature correction, as they are treated at length in all standard works on surveying. In Philadelphia some of the survey districts arbitrarily make an allowance of 0.02 ft. for each 100 ft. as a temperature correction, deducting that amount in summer and adding it in winter. A more scientific method is to attach one or more delicate thermometers to the tape, and make an actual allowance of 0.01 ft. in 100 ft. for each 16° variation from the standard of 62°.

EXPERIMENTS ON THE ESCAPE OF STEAM THROUGH ORIFICES.*

By M. Rateau.†

The calculation of steam turbines depends upon the knowledge of the laws which determine the escape of steam through converging or converging-diverging orifices. In order to verify exactly the formulas for the escape of steam, the author undertook, in 1895-'96, at St. Etienne, a series of experiments on this subject, according to a method which gives the greatest possible precision. A short indication of these experiments has been given in the report on steam turbines which the author had the honor to present last year at the International Congress of Applied Mechanics in Paris. But at this time he had not yet completed all the calculations of the results of his experiments, whereas now he is able to give an account of the results. They differ a little from those the author provisionally announced at the Congress of 1900.

*A paper read before the International Engineering Congress at Glasgow.
†Paris, France.

Those investigators who experimented before and since the author, namely, Minary and Résal in 1861, Peabody and Kunhard in 1890, Parenty in 1891, Miller and Read in 1895, and Rosenheim in 1900, have all used the same method, which consists of condensing in a surface condenser the steam, which escapes by the orifice for a sufficiently long period, and then weighing the condensed water. But this method, beyond being very laborious, cannot give great precision, because in the first place it is very difficult to keep constant the initial steam-pressure (pession d'amont), P, during the whole of the experiments, and the steam, being never absolutely dry, the wafer which it carries with it is weighed with the condensed water, so that the results found must be generally over-estimated.

The author therefore proposed to remove these causes of error so as to obtain exact results within two-thou-

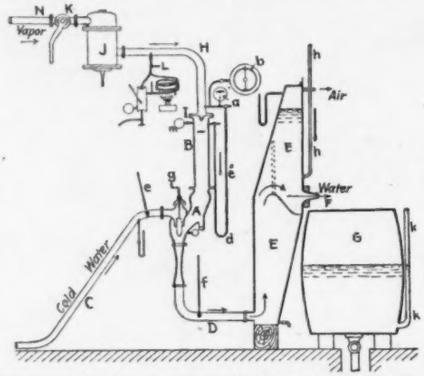


Fig. 1. Sketch of Apparatus for Determining the Escape of Steam Through Orifices.

sandths, and to use besides sufficiently large orifices to deliver up to more than 900 kilos (1,980 lbs.) of steam per hour.

He has reached the desired result by condensing the steam in a stream of water with the use of an ejector-condenser, and by measuring the total yield of water and the initial and final temperatures of this stream. Thus he was able to make all the readings at the same moment, as soon as constant conditions were obtained; and each experiment did not last more than one or two minutes. It has been possible thus without much trouble to make more than 140 observations under the most varied conditions.

Fig. 1 represents diagrammatically the apparatus employed. A is the ejector-condenser which receives steam through the pipe B, and cold water by the pipe C. The hot water containing condensed steam escapes by the pipe D into the sheet-iron chamber E, where the air separates out; then it goes out through the converging orifice F at a pressure measured by the water gage hh.

The rise in temperature of the water is measured by the thermometers e and f, graduated to twentieths of a degree, and previously calibrated in comparison with a Baudin thermometer.

The nozzle to be tested is placed within the pipe at I. It receives the vapor through the pipe H, 50 mm. (2 ins.) diameter, and throws it into the large pipe B of 120 mm. (4.8 ins.) diameter. The initial pressure P (à l'amont) was measured by one or other of the gages a b. The resultant pressure p (à l'aval) was measured by either the metallic pressure gage m, or the mercury gage d.

The steam, arriving from the boiler by the pipe N, rushes with centrifugal force into the separator on account of the partial vacuum therein, and the small quantity remaining can be measured by the specially arranged apparatus L.

The author was thus assured from the beginning of his experiments that the quantity of water passing the separator never exceeded 0.002 to 0.003, and as the error due to this method could not exceed a quarter of this amount, or an insignificant figure, he has neglected it.

The pressure before passing the nozzle could be regulated at will by means of the cock K; a special valve, actuated by the crank g, enabled the pressure p (aval) to be fixed at any desired amount above the lowest pressure caused by the ejector-condenser. The author has thus been able to operate through a long range of pressures, from 0.12 to 12 kilos per sq. in. (0.22 to 26.4 lbs. per sq. in.) The rate of flow through the water orifice F had been previously measured with great care by means of the barrel G graduated along the tube KK.

The author has experimented successfully upon a thin-walled orifice, and upon three converging nozzles having respectively a diameter at the narrowest part of 10.49, 15.19 and 24.20 mm. (0.41, 0.59 and 0.95-in.).

Without entering into detail of the figures involved in these calculations, Fig. 2 gives in graphic form the results obtained with converging orifices, in all cases where the subsequent pressure p (aval) was less than 0.58 of the initial pressure P. The points indicate the ratio $\frac{I}{P}$ rate of consumption in grammes per second and per sq. cm. of orifice, at the absolute pressure P (d'amont) in kilos per sq. cm. for different values of P.

There are 59 results which approximate to the theoretical straight line AB, calculated from Regnault's tables by the thermo-dynamical formula, assuming that the mechanical equivalent of heat is equal to 425 kilos (774 ft.-lbs. per B.T.U.) per calorie. The differences do not usually exceed 2%. The mean of the results gives a figure 0.007 in excess, when compared with the theoretical calculation. This difference may be due to the displacement of the thermometer zeros (of 0.1 to 0.2 degree) during the course of the trials. It will be observed that this would not exceed 0.0035, if one assumed for the theoretical calculation a value 428 for the mechanical equivalent E, which is now admitted; for the formula of the speed of escape includes $\sqrt{2\,g\,E}$ as a factor.

The scale of ordinates in the figure is contorted on account of the method of recording small differences. To show clearly the value of the differences, straight lines a b and a' b' have been drawn on Fig. 2. These differ from the theoretical line by 1% more or less respectively. The line C D corresponds to Grosshof's formula.

$$I = 15.26\ P^{0.9896}.$$

The correspondence between the theory and the practice is satisfactory. If is the same when the subsequent pres-

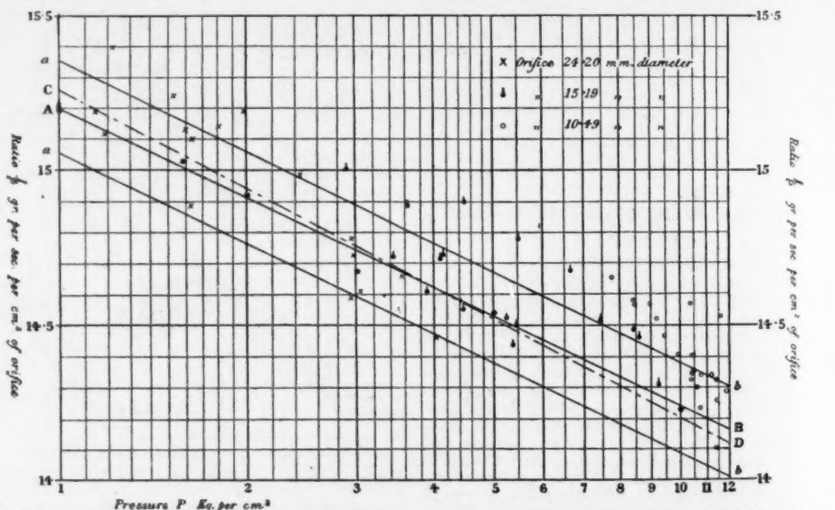


FIG. 2. DIAGRAM ILLUSTRATING EXPERIMENTS ON ESCAPE OF STEAM THROUGH CONVERGING ORIFICES.

sure p (aval) exceeds 0.58 P, in which case the consumption of steam depends on the two pressures p and P simultaneously, whilst the consumption depends on P only if p is less than 0.58 P.

In the latter case the consumption may be very exactly represented by the formula

$$I = P\ (15.20 - 0.96 \log P),$$

I being the consumption in grammes per second and per sq. cm. of orifice, and P the initial pressure in kilos per sq. cm.

THE BUTLER STEAM SHOVEL CABLEWAY AT THE MISSIONFIELD COAL MINE, ILLINOIS.

The use of steam shovels in the open pit iron mines of the Lake Superior region and the enormous outputs of ore secured by their use are familiar to engineers. In the accompanying cuts we illustrate an excavating and conveying device designed for similar open pit mining and employed at the Missionfield, Illinois, mines of the Consolidated Coal Co. of St. Louis, Mo., with remarkable success. This machine is called by the builders a steam shovel cableway. As will be seen from the illustrations, the device consists of a car supporting a framework tower from which an approximately horizontal boom extends over the pit, at the bottom of which excavation is in progress. At the outer end of this boom is a vertical sheave between which and the operating machinery on the car are rove a series of cables attached to a scoop or scraper in such a manner that it can be dragged across the bottom of the pit and filled, then hoisted and dumped, and finally returned for a fresh cut. The construction of the tower is very simple, and neither it nor the operating machinery call for particular mention.

The Missionfield strip coal mines, where this excavator is used, are situated on the Cleveland, Cincinnati, Chicago & St. Louis and the Chicago & Eastern Illinois railways, about five miles west of Danville, Ill. The coal in Vermillion County, that is known as the Danville vein, lies about 100 ft. below the normal surface of the ground, but in some places in the river bottoms the surface has been washed away forming a broad valley through which the river runs. The Missionfield is located on one of these bottoms, with about 20 ft. of earth and soapstone overlying the coal. For many years the farmers and other residents of the neighborhood secured their coal from these bottoms before any regular mines were started. In 1889 large steam shovels were introduced, and mining operations commenced on a larger scale. These shovels are stated, however, to have worked with very indifferent success, and in 1894 the excavating and conveying device here illustrated was substituted.

The method of working these excavators is to take a large tract of land and excavate first a channel or dry canal along one edge or boundary. In making this excavation the excavator travels along a track on the inside bank of the cut with its boom extending over the cut and the spoil area on the opposite bank. The overburden of earth and rock is first removed and dumped on the spoil bank and then the coal is taken out and loaded on cars. This completes the work on the first cut. The next operation is to move the excavator tracks back from the channel bank a suitable distance to enable another parallel channel to be excavated. The spoil from this second cut is dumped into the first channel and fills it. A succession of these operations finally removes the coal from the entire tract.

Turning now to the illustrations, Fig. 1 shows two of the excavators at work; the one in the foreground is removing the earth and soapstone and depositing it at the end of the boom on the spoil bank 120 ft. from the track, and the one in the background is taking out coal. It is stated that the excavator used for removing the overburden readily digs any earth, and by means of a specially-designed plow, loosens up and shovels with ease the hardest soapstone and "black-hack," the lumps of which can be seen in the foreground of the picture. Fig. 2 is a view showing the coal excavator shovel in the process of dumping its load on the cars. As will be seen, the coal is discharged from the shovel with practically no drop, thus reducing breakage to a minimum. In conclusion, it may be noted that the builders of these machines assert that they will dig and handle cement rock, hard pan, conglomerate, and loose rock, with entire success. This steam shovel cableway, as it is called, has been patented and is controlled by Butler Bros., of Danville, Ill., to whom we are indebted for the matter from which this description has been prepared.

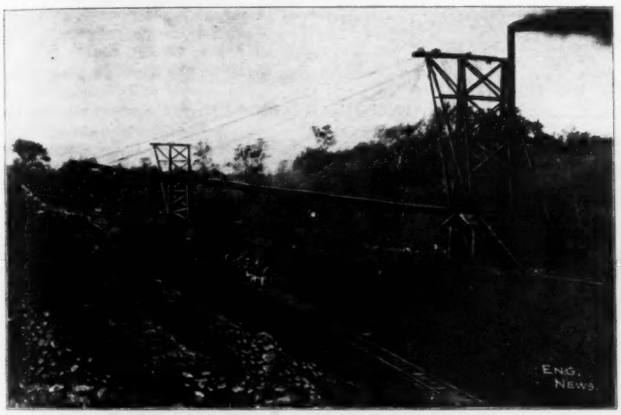


FIG. 1. BUTLER STEAM SHOVEL CABLEWAYS MINING COAL FROM OPEN PITS, MISSIONFIELD MINES, ILLINOIS.
Butler Bros., Danville, Ill., Builders.

FIG. 2. BUTLER STEAM SHOVEL CABLEWAY IN PROCESS OF DUMPING COAL ON CARS.

SOME LESSONS FROM THE MACADAM PAVEMENTS OF ALBION, N. Y.

By Halbert Powers Gillette.*

The village of Albion, N. Y., has some 35 miles of streets, about half of which are paved with Medina sandstone macadam. As sandstone has usually been pronounced by authorities on highway construction to be unfit for road surfacing, the experience of Albion, a place of 5,000 inhabitants, may be a valuable guide to others. Besides the use of sandstone in Albion there are several other economic features of considerable importance which will be brought out as we proceed.

About five years ago the village bought a 15-ton steam roller and began in earnest the betterment of its then wretched streets. To-day, with more than half its streets excellently paved, it would be difficult to find a more attractive village. The credit of this excellent street work is in large part due to the village president, Mr. G. W. Ough, and to Mr. P. J. Stock, the present street commissioner, whose ingenuity in devising methods of reducing cost is especially worthy of commendation.

While there is considerable variation in the width of streets, the average is about 28 ft. between curbs for residence streets. Of this, 18 ft. is paved with 6 or 8 ins. of sandstone macadam, leaving a 5-ft. earth shoulder and gutter on each side. A feature that first strikes the eye of an engineer is the very sharp crown, which I found to be about 1 in. per ft., or a center rise of 14 ins. above the gutter in a street 28 ft. wide. The next noticeable feature is the cleanliness of the paved portion of the street. My visit was made after a heavy rainfall. I found the earth gutters covered with a thin layer of fine material evidently washed off the macadam by the rain. Hitherto I have advocated a rather flat crown, about ½-in. per ft., in order not to concentrate traffic at the center of the road. But in a village street, especially if the macadam is of stone that wears rapidly, it is evidently far preferable to resurface the street more frequently as a consequence of giving it a sharp crown, than to have a dusty or muddy street which, costing considerable to keep clean by hoeing, is generally left until it becomes positively unbearable. It is true that the material washed by rains into gutters must eventually be removed, but this is much cheaper done at long intervals when greater quantities are to be handled. Moreover, since the gutters in Albion are of earth, a Shuart or other leveling scraper can be used to scrape up the detritus and deposit it in piles for removal; whereas such a scraper loosens the surface of a macadam road and should not be used for cleaning macadam.

On country roads made of hard rock and swept by winds, a flat crown is desirable, but where the conditions are as in Albion a very sharp crown is evidently to be preferred. We have next to consider the material of which the macadam has been made, namely, Medina sandstone broken by hand by old men working on the waste rock of nearby quarries.

Turning to the Sixth Annual Report of the Massachusetts Highway Commission, we find that by the rattler test Medina sandstone has a coefficient of wear about the same as Rockland Lake trap, whence it might be inferred that they would show about equal wearing qualities in a road. There is, however, a much greater uniformity of hardness in trap. This insures a more even surface wear under traffic than is to be found in sandstone, which, like brick, appears to give way in spots that rapidly grow larger. The rattler test fails to show one great source of wear in a road, namely, the crushing of loose fragments that, having been picked out by horses' calks, are ground to powder under passing wheels. This source of wear is greatest where the binding quality of the rock is least, thus placing a hard rock like trap more nearly on a par with a soft limestone than the rattler test would indicate. Whatever laboratory tests may indicate, it is certain that the Medina sandstone on the main street of Albion, under a heavy traffic, has lasted 5 years without resurfacing, and is only just reaching an uneven condition that renders resurfacing necessary. Several of the residence streets are still in excellent condition after 5 years' wear.

In this connection it may be well to call attention to an error that I myself have made, and one that others as well have fallen into, namely, reasoning that if trap rock wears twice as long as limestone, for example, it will pay to use trap even if it costs double what limestone does. This is far from being true, as the following table clearly shows, for the interest charge is one that entirely modifies the problem:

Material.	Annual charge, per sq. yd. Annual wear.	Interest at 5%.	New material.	Total.
6-in. limestone macadam..	0.5-in.	1.5	2.5	4.0
6-in. trap macadam.....	0.1-in.	3.0	1.0	4.0
2-in. limestone macadam...	0.3-in.	0.5	1.5	2.0
2-in. trap macadam.....	0.1-in.	1.0	1.0	2.0

Note.—Limestone macadam assumed at $1.80 per cu. yd.; and trap macadam at $3.60.

*791 Powers Block, Rochester, N. Y.

From the table it is evident that in a 6-in. road, limestone may wear five times faster than trap, prices being as given, and yet be no more expensive annually; while if a 2-in. surface coat is used limestone must wear more than three times faster than trap to be less economical, at the cost and rate per cent. assumed.

We have seen the New York State Engineers rejecting Medina sandstone entirely for road surfacing when by the rattler test it should have almost as long a life as trap, and by the actual test in the streets of Albion it has proven a satisfactory pavement material.

Passing now to the method of construction used by Mr. Stock, I learned that no attempt was made to grade to any established line. Mud holes were cleaned out and stone thrown in to fill up to the general subgrade level. While I think it is usually good practice not to tear up an old village street that by years of traffic has secured a hard earth crust, I believe hollows should be filled up and the crown of the subgrade secured by use of gravel or cinders. Albion, however, is peculiarly situated, in that the broken stone is quite as cheap as gravel. As Mr. Stock remarked, nine out of ten civil engineers if called upon to design and lay out pavements for Albion would have made their survey, established uniform grades and excavated or filled thereto regardless of whether in so doing the old road crust would have been destroyed or not. In consequence the cost of the work would have been increased, while at the same time the supporting power of the subgrade would have been diminished. The opinion seems prevalent that if a ten-ton steam roller be used, a subgrade can be compacted quite as much as by wagons and hoofs. In the same length of time it might be nearly so, but let it be remembered the process of forming an earth crest on a road is one that has usually required years. Wagon wheels not only compress earth better than a roller, but in addition they grind some of the coarser particles into dust, which is washed down into the voids below by rain. A repetition of this dust-forming process, puddling by rains, and rolling by wheels, will in a few years form an earth crust 4 to 6 ins. thick; a crust so hard that four horses on a pick-pointed plow will often loosen it with greatest difficulty. Such an earth crust is in fact a sort of macadam made of fragments of Lilliputian size; the greatest objection to it being the absence of uniformity, and ordinarily the excess of dust.

Generally, we may say, an earth crust should not be broken up for the sake of securing a uniform grade, for the engineer should remember that the eye cannot detect a rise or fall of several inches in a hundred feet of road; and even were it noticeable to an expert, to those who use the road it would not be.

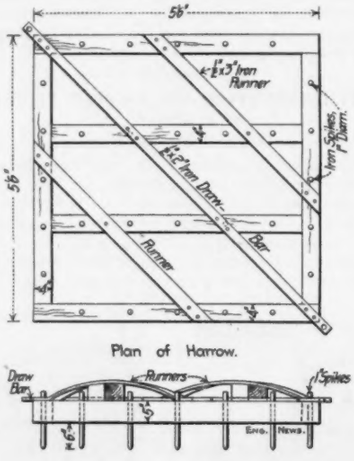
To continue the road-making process: The sandstone is well rolled with a 15-ton roller; a lighter 10-ton one would suffice, but a heavy 12 or 15-ton roller is much better for spiking up an old road when it comes to repairs.

The sandstone, which, let it be remembered, has no screenings, being hand broken stone, is more or less broken into smaller fragments by the roller. When rolled solid enough to support a wide-tired wagon without displacement of the rolled stone, wagons loaded with sand and loam are driven on. This is spread with shovels in a thin layer and washed down into the voids with a sprinkling cart or hose. After the surface is dry enough so that it will not stick to the wheels it is again rolled. Spreading of sand, puddling and rolling are repeated once more before the surface is satisfactory. No finer road surface could be desired than is produced by the method described, yet we find the State Engineer building a road not 25 miles from Albion and rejecting all sandstone screenings, and all stone below 1¼ ins. diameter, and importing limestone screenings from the Hudson River, all because "experts" do not approve of methods and material that are not theoretically perfect. In addition to the extravagance in wasting 40% of the crusher output, we find trap rock used to cover the same road, although the Medina sandstone in Albion has served five years as a road surfacing material, and on many of the streets is not yet in need of resurfacing. I believe in theories, but in theories that explain phenomena, not in those mental conceptions of how materials should behave under stress before actual tests have been applied; conceptions that are misnamed "theories," when they are only hypotheses. In road-making there has been too much hypothesis and not enough true theory.

Mr. Stock's observation agrees with mine (Engineering News, June 6, 1901), that resurfacing is not ordinarily required oftener than once in five years, although wherever bad chuck holes appear patching should be done.

In the issue of Engineering News just referred to, I gave some data of the cost of repairs by the intermittent system. Through the courtesy of Mr. Stock I am now able to give some figures that show even a less cost per mile for repairs.

Using the method that I am about to describe, Mr. Stock succeeded in picking, resurfacing and rolling a stretch of macadam 18 ft. wide by 1,000



Sketches of Harrow Used on Macadam Road Repairs at Albion, N. Y.

ft. long in two ten-hour days; one day in spiking up the old surface with the picks in the steam roller and one day in re-rolling. As the surface was loosened to a depth of about 4 ins., it will be seen that over 200 cu. yds. of macadam were compacted by the roller in 10 hrs. The point to which I wish to call attention is not so much the extraordinary rapidity of the rolling as the very ingenious method devised by Mr. Stock for completing the loosening of the macadam after cracking it up with the roller spikes. For this purpose Mr. Stock built a heavy harrow, similar to those used on farms, the accompanying sketches showing its detail design. By turning the harrow upside down it rides on the runners shown in the figure, and is thus transported when not in use. A heavy team of horses is used to drag the sharp-pointed harrow over the macadam after it has been loosened as much as possible with the spikes of the steam roller. The spikes in the harrow not only complete the breaking-up of the crust as well as could be done by men using picks, but in addition the spikes spread the loosened stone, filling up all low places.

The total cost of resurfacing was:

	Per sq. yd.
Roller and engineer at $1 per hour picking.....	0.5 ct.
Roller and engineer at $1 per hour re-rolling....	0.5 "
Sprinkling, with cart, 40 cts. an hour (1 day)....	0.2 "
Harrowing, team & driver, 30 cts. an hr (2 days)	0.3 "
Total	1.5 cts.

At this rate a macadam road 16 ft. wide and a mile long can be resurfaced for less than $140, or about half the cost given in my article above referred to. The cost of resurfacing has, therefore, been only $30 per mile per annum! Yet we are told that it is practically impossible to maintain macadam roads and pay interest on investment for $320 per mile per annum. (See discussion in Engineering News, April 25 and May 9, 1901).

The record made by Mr. Stock is indeed a remarkable one, and a record that few villages may hope to see attained unless by accident they secure an able Street Commissioner. In addition to the labor item there were some 75 cu. yds. of stone furnished, which it was estimated would bring the road up to its original crown. The stone cost about $60, delivered, and was spread by two men in two days at a cost of $6. By using a Shuart grader the item of spreading could have been reduced to $1.50.

For new materials we have, therefore, a trifle over $60 per mile per annum, making a total of about $90 per mile per annum for labor and material for resurfacing a Medina sandstone road. Of course, the loss of material by wear was not accurately measured, but it was less rather than more than the amount put on for repairs. At this rate, the annual vertical wear was about 0.2-in over the whole surface.

Let it be remembered that this was a main traveled street, where farmers' teams enter the village, and that the residence streets may last another five years without resurfacing. In the face of such facts as these, I ask engineers who have condemned sandstone macadam for village streets and roads to give something beside abstract reasoning as a basis of their contention. One "authority" has unhesitatingly condemned all macadam of every description for street pavement, as being a penny wise and pound foolish investment. Albion is only one of many places that have not found it so.

It is not a sufficient argument to point to one example (Toronto) where the macadam "streets became seas of mud," as does Mr. W. P. Judson, in his pamphlet on "City Roads and Pavements," and therefore conclude that macadam is unfit for city or village pavement; for it must be conceded that if poorly made, of very soft or shaly rock, of insufficient thickness, upon poorly-drained soil, macadam is sure to become "seas of mud." And in this connection it may be well to take issue with one of the "theories" of the same author, who says, "Mud is the deadly enemy of broken-stone roadways, working in between the small angular fragments of stone which have been made and placed with so much care, crowding them apart and destroying their firmness and mutual support." In order to avoid tracking on mud the author adds, "It is thus evident that to secure a reasonably good result, not only the main street (of Oswego), but all its branches should be macadamized at about the same time. This seems hardly practicable."

Over and against all this "theorizing" I set Albion, and the refutation of such generalizations is complete.

Mud is not the "deadly enemy of macadam;" for while not pleasant, it really tends to preserve the macadam from the calks of hoofs, and to keep the macadam from drying out and raveling.

I have seen a good many excavations made in old macadam, where it was and always had been very muddy, but of the insiduous "crowding apart" of the fragments by mud I have yet to see an example. In glancing along the pages of this same pamphlet, I read again the old, old story of European experience in maintenance. In Paris, we are told, roads have worn down at the rate of almost 19 ins., vertically, every year! I can readily conceive that this might be possible under an enormous traffic, where a soft loose stone was dumped upon the road, without rolling, and consequently pulverized by passing wheels, which was very likely the case in Paris; but it is exceedingly misleading to cite any such prehistoric example in arguing against macadam.

Why go to Paris for precedents, when better ones are to be found right at our doors; and precedents wherein all the factors are known, so that conclusions based thereon are likely to be somewhere near the truth?

It is interesting to add one more quotation from Mr. Judson's "City Roads and Pavements," for it gives not only his opinion, but that of others whom he has copied, which is:

> Sandstone is wholly unfit for any but country roads of light traffic, grinding quickly into dust and mud, so that it is poor economy to use it anywhere. This, of the variety known as gray sandstone, is the only rock of which Oswego has a supply.

Prof. N. S. Shaler, in his "American Highways," p. 63, says:

> The sandstones, except where they have been converted to quartzites or cherts, are also to be passed by in road construction, except where no other means of bettering the way are available. They are practically without binding value, and in almost all cases the fragments quickly go to

pieces under the tread of wheels. Any important main way which lies in a district affording nothing better for road-building than sandstone can often, in the long run, be more economically made by the use of brick pavements, which, though costly in their first construction, are in the course of ten years less expensive than sandstone roads.

Fortunately for Albion no "experts" were called in when pavements were contemplated, or they might even now be wallowing in mud waiting for the day that brick pavements could be afforded. Expert advice is not in consequence to be ignored, but when such advice is given let it be based upon experience in actual use, and not upon mental conceptions.

WORKSHOP METHODS.*

By Messrs. William Weir and J. R. Richmond.†

So many papers have been written, and so much literature now exists on the equipment and organization of engineering works, that a brief consideration of some less frequently treated factors in promoting efficiency in the shops may be of interest and possibly of value.

No claim to novelty is made on behalf of these schemes, as several of them are of trans-Atlantic origin, but their success when transplanted to this side shows that much can be done to interest the men and the staff generally in their work, and to stimulate the initiation of improvements. It is as true to-day as when John Stuart Mill wrote that "Capitalists are almost as much interested as laborers in placing the operations of industry on such a footing, that those who labor for them may feel the same interest in the work, which is felt by those who labor on their own account"; in fact, the greater division of labor and specialization of product, which are the features of modern shops, require not only improved environment for the workers, but also some additional stimulus apart from the daily round, to promote a live and healthy spirit, if a high grade of efficiency is to be kept up in an establishment.

The schemes to be described have now been in operation for some time, so that a fair idea can be given of their working results, and it is the experience of the authors, that when judiciously introduced and governed by commonsense principles, they furnish most valuable assistance in the conduct of business. The descriptions of the various efficiency factors following, are not intended to be exhaustive, but rather suggestive sketches embodying practical points which experience has shown to be essential.

1. PREMIUM SYSTEM OF REMUNERATING LABOR.‡

In an engineering works which for many years has worked with only time wages, workmen who have been employed for a long period in the establishment obtain generally a higher hourly rate than workmen who have only been employed for a comparatively short period, due to their supposed better acquaintance with the work, but in many cases younger and fresher men are better and more productive men than the "old timers," so that the relative wages do not therefore represent the relative values of the men.

To remedy this state of affairs and to obtain a system whereby every man receives the same standard rate of wages, and in addition an extra remuneration for any increase over a normal basis rate of production, it was decided, after considering all the best known systems of remuneration, to adopt the Premium System, for the following reasons:

1. The system was simple in its conception and easily understood by the men, their extra remuneration being easily calculated by themselves; the differential rate system being open to objection on this point and tending to lead to friction between the men and the administrators of the system.

2. The system was comparatively simple in its application and did not involve a very large additional staff. In the works in question about 500 men work under premium and the staff numbers five men and two boys, including the superintendent.

3. It had not the defect of piece work, that an error in rate fixing is either expensive or discouraging. An error in premium rate fixing only affects the premium, not the wages.

4. It offered a real inducement to the workman to suggest improvements in his machine or tools. Under the piece-work system, so long as the machine was kept up to a certain standard condition of fitness, the man said nothing, as any improvement he was aware would probably result in cutting his rate. Under the premium system an improvement suggested by the man benefits him and the employer, also, as within reason no rate cutting is found necessary.

5. The system in its application gives accurate data for time-keeping and cost-keeping purposes. It acts as a double check on the time-keeping, and it associates on one form the article, the operation and the time cost.

Many different applications are in existence of this system, most of which are excellent, but in considering their application the character of work being done under the system largely influences the correct choice. In our works there is a large amount of repetition work and also a large amount of special work, but in no case are the operations carried out under a premium contract of longer duration than about 50 hours. We therefore adopted the system of paying a premium of 50% on the time saved.

The following table shows the result to the workman of the application of the system:

Part.	Operation.	Hours. Allowed.	Hours. Taken.	Hours. Saved.	Rate of wages per hour.	Workman's earnings.
10-in. cast-iron pump.	Boring out.	40	24	16	8d.	24 hrs. at 8d. + 16/2 at 8d. = 21s. 4d.

It will thus be seen that the workman has earned a premium of one-third of his wages on this contract.

CONTRACT NOTE.

No.....
Job No..... Machine No.....
Names..... No.....
..... No.....
No. of pieces.....
Article, ...
Ope ation .....
.....
Time allowance .....
Commenced .....
Finished .....
Time Taken .....
Time Saved .....
Work and Time Checked.....
Remarks: .....

TIME CARD.

No.....
Job No..... Machine No.....
Names..... No.....
..... No.....
No. of Pieces .....
Article. .....
Operation .....
.....
Commenced .....
Finished..... .....
Time Taken .....
Work and Time Checked.....
Remarks: .....

(The cards used for contracts are reproduced in condensed form herewith.—Ed.) The Contract Note is self-explanatory. The Time Card is used when no time allowance has been fixed for the operation in question, and the larger part of the superintendent's duties are in watching the execution of work done under these cards, to enable a suitable rate to be fixed for use when the operation recurs. The men obtain their cards from the premium office, situated in convenient parts of the works; the time for commencing the operation being the time at which the card leaves the office, the finishing and commencing time of the cards coinciding; thus the preparation time for a job is considered and allowed for in the time allowance In case of special machines requiring a considerable time to adjust tools, etc., this allowance bears a ratio to the number of pieces to be done. On the completion of a contract the note is check punched by the inspector, or the foreman of the department, who thus certifies the job to be done correctly and the full operation denoted on the card to have been carried out. To prevent any chance of scamping or bad work, a strict rule is enforced that if any part of the work, however small, done under the contract is not right, the man loses his whole premium under the contract. After consultation with the men it has been agreed to pay the premium every four weeks, except before the two main holidays in July and December, when eight weeks are allowed to lapse before payment.

After more than three years' experience of the working of the system we have found the following to be among the many advantages gained by its application:

1. It has resulted in a largely increased output from our machines for the same labor cost.

2. An increase in our workmen's average drawings of from 10 to 40%.

3. In the practically compulsory maintenance of our machines in the highest state of efficiency.

4. In a greatly increased interest of the men in their work, machines and equipment, and a fair amount of co-operation in all our schemes for improving our factory.

5. It has given our foremen a field for the choice of men we never had previously, resulting in the employment of only the best class of steady workmen.

6. It has caused our foremen to be no longer merely taskmasters over the men, but to become more providers of work for them and inspectors of that work.

2. THE FRICTION CLUB.—In every establishment shop-problems of various kinds occur, the settlement of which affects different departments. It is not always convenient to get the different foremen together during the day's work to decide on these problems, and any discussions during working hours are apt to be hurried and conclusions come to which maturer consideration may condemn. Data have frequently to be collected, and the points affecting different departments investigated thoroughly before a decision can be arrived at. There are also many suggestions of improvement made casually which may be recognized as good and worthy of adoption, but even the best shop manager is unable always to follow them up and see that they are carried to a conclusion. Further, after a suggested improvement is put into force it is frequently lost sight of, and its results become unascertainable.

To secure a proper discussion on shop problems and to provide machinery for the systematic carrying out of suggestions and reporting of results, it was decided to inaugurate at our works a club composed not only of foremen, but of all the administrative heads of departments, drawing office, cost department, correspondence department, etc.

When the club was first proposed, its reception was not at all favorable; it was considered by the foreman that the discussions would breed dissension, that reflections would be made by one foreman on the work of another, and that generally it would give rise to internal friction. It was accordingly named the "Friction Club," on the principle that its mission was to be the elimination of friction. Its business was to discuss shop problems and decide on solutions, to institute improvements and provide the means of carrying them out to finality, to receive and adjudicate on complaints and suggestions. Its rules were made as elastic as possible. Its office-bearers consist of an executive committee of five, three chairmen, who preside in succession, and two joint secretaries. Meetings are held once a month in the evening; the proceedings are reported and copies are neostyled and given to each member for insertion in a spring binder with which he is provided. The business of each meeting is arranged by the executive, and deals with whatever shop questions are most pressing.

A club letter-box is provided in the shop into which members are requested to send notes on suggestions or subjects for discussion. This box is opened by the executive committee prior to the issue of the notice for the following meeting, and if any matter requiring discussion is received in the box it is incorporated in the business for that meeting.

The club was started at first with some misgivings, but it has steadily improved and has taken its place as a most helpful factor in our establishment.

Among the matter dealt with by the club have been the following:

1. The establishment of a works library, containing books and current technical papers and magazines. The weekly technical papers are available for members of the club one week after publication, the monthly magazines one fortnight. Books can be borrowed at certain hours from the library, and the private technical libraries of members of the firm are made available to members on application. 2. The workingmen's suggestion schemes, as described later in the present paper. 3. The admittance and course of apprentices in the works. 4. The lighting of the shops. 5. The arrangement of the firm's exhibit at the Glasgow International Exhibition. 6. The distribution of shop laborers. 7. Shop hindrances—a report by each foreman on his department, indicating the hindrances interfering with the execution or output of the work of his department. 8. Grindstones versus emery wheels. 9. Wearing of overalls, by the men, etc.

The decisions of the club are, where necessary, submitted to the directors and receive their sanction before being put in operation, but as each of the three chairmen of the club are directors, this is usually a matter of form.

3. THE WORKINGMEN'S SUGGESTION SCHEME.—Closely allied with the Friction Club is another efficiency factor which has recently been inaugurated in our works, namely, the Workmen's Suggestion Scheme. Encouraged by the success of the first few meetings of the Friction Club, it seems a logical sequence that suggestions for improvements and reforms should be asked from the workmen themselves. Knowing generally the lines on which a similar scheme had been worked by the National Cash Register, of Dayton, O., it was felt that with modifications some means could be attained by which the intelligence and observation of the workmen themselves might be encouraged and directed. Accordingly a scheme was promoted and discussed by the Friction Club, its purpose being to encourage the workmen to make suggestions for improvements in the shops, and on the work generally. The directors of the company agreed to allot a sum of $20 per month for the best suggestion, or suggestions, made by workmen by means of which an improvement could be effected on the machine tools, hand tools, jigs, fixtures, work methods, organization, cleanliness, order, or other matters affecting the shops. All suggestions are signed with the workman's name and shop number, also a note stating whether the suggestion is original or taken from a technical journal or other source. The written suggestions are placed by the author in a box provided in the gate-house. This is opened daily by the club secretary, and the suggestions received are stamped with a date stamp when taken out and are considered in order of priority. The judgment and discussion on the suggestions is conducted at the Friction Club, and also the allocation of the awards, the amount being given according to their decision in one or more sums according to the merits of the suggestions.

In deciding upon the awards, those suggestions which are considered of little merit are first eliminated, until gradually the best are left, and if any difference of opinion exists as to the comparative merits, they are voted upon.

*Slightly condensed from a paper read before the International Engineering Congress at Glasgow.
†Glasgow, Scotland.
‡See Eng. News, July-December, 1891, p. 61.

The names of the suggesters are not given to the meeting, but are known only to the executive committee. The successful suggestions each month are posted on a notice board provided for the purpose, but the names of the suggesters are not published.

If the merit of the suggestions is such that the awards do not absorb the entire $20 in any one month, the balance is carried forward and serves to augment the award for suggestions which may be considered of special merit.

During five months the total number of suggestions received amounts to 60; 3 the first month; 11, 8, 18, and 20 in the succeeding months; and of this total the number of suggestions adopted and carried out amounts to about 20% of those received, and are grouped under headings as follows: (1) Cleanliness and order; (2) improvements in machines or methods; (3) shop fittings; (4) safety devices; (5) general.

The discussion on these suggestions has been most educative, and has resulted in several most excellent shop devices. The scheme has also been well taken up by the apprentices and has directed attention to the men who can be drawn upon for promotion to responsible posts.

4. THE TECHNICAL COMMITTEE.—It will be noted that the Workmen's Suggestion Scheme does not include in its scope suggestions for improvement on the designs of the firm's product. It was considered that this would be likely to involve complications and give rise to difficulties. Accordingly the function of dealing with designs, etc., lies with a committee comprising the managing director, shop manager, chief draftsman, and draftsman on special design. This body is called the Technical Committee, and besides the above members it can call to its deliberations any foreman or other administrative head, whose advice is required. It deals with the revisal of the designs of the firm's product, the carrying out of experimental work, the tabulation of results, the systematic consideration of complaints and defects, and the criticism and development of new designs. Further it considers the complaints which have been received by the correspondence department, and the reports of the firm's engineers who have been depufed to examine and rectify them. Each month the complaints and reports of defects received by the correspondence department are collected and tabulated under distinctive heads, and these are considered in relation to the design of the product.

The Technical Committee suggests modifications or carries out experiments to obtain data, and reports upon the results. It deals with new designs from the point of efficiency, cost of production, and commercial advantage. In the author's experience the systematic tabulation and analysis of complaints is a most valuable help towards the elimination of small defects. In the rush of a busy day, a single complaint may be received, and the temptation is great simply to blame the personal element for neglect or carelessness and to minimize its importance. But when complaints of a like nature are classed together and tabulated over a period, they have the force, not of single spies, but of battalions.

5. THE INTELLIGENCE DEPARTMENT.—In discussing business principles Sir J. Wolfe Barry has mentioned as a most vital one "the necessity of keeping 'au courant' with what is being done or contemplated by others in similar lines of business, and of being well in touch with all probable new developments, whether of applied science or of labor-saving expedients, not merely in this country but among our world-wide competitors." The Intelligence Department deals with the collection of information and data required by the various departments and members of the firm; the indexing, cataloguing, and filing of technical literature, catalogues, cuttings, etc. It secures a systematic perusal of contract advertisements in the technical papers, marks and records openings for the firm's products and keeps a card index of parties interested or likely to be interested in them. The principals or heads of departments furnish notes of special subjects on which they desire information, and articles in current magazines or papers are marked for their perusal. When the subject is a general or voluminous one, such as wafer-tube boilers, Romeike and Curtis can be requisitioned. The technical index of the "Engineering Magazine" is also utilized and special articles are obtained by coupon when required. These cuttings are filed under department or subject heads in cardboard cases for reference.

Suppose the firm is considering any problem, say foundry equipment, the Intelligence Department is requested to collect the articles dealing with this subject, the various yearly indexes of technical papers are gone over, and if need be a summary is prepared for the Technical Committee, or the individual member to whom the question has been remitted. This method saves the time of the more expensive staff, and is a means of readily obtaining concentrated information with a minimum expenditure of high paid labor.

The duties of this department are of course not continuous, but intermittent, and are combined with other clerical duties. In the establishment here dealt with they are undertaken by ladies, whose natural genius for detail makes them specially suited for this class of work.

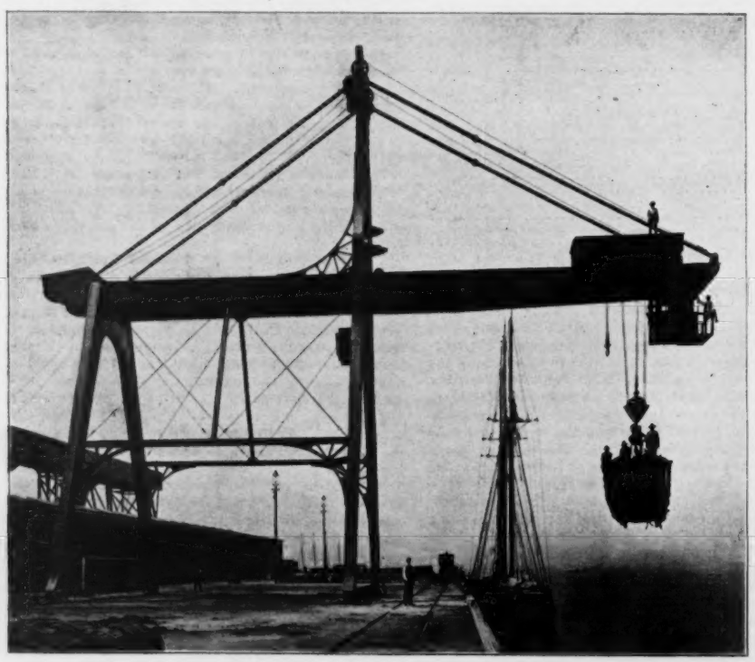


FIG. 1. VIEW SHOWING CRANE WITH LOAD AT END OF LEAF. FIG. 2. VIEW SHOWING CRANE WITH LEAF FOLDED UP.

30-TON FOLDING GANTRY CRANE FOR THE CHESAPEAKE & OHIO RY. WHARVES AT NEWPORT NEWS, VA.

Designed and Built by the Wellman-Seaver Engineering Co., Cleveland, Ohio.

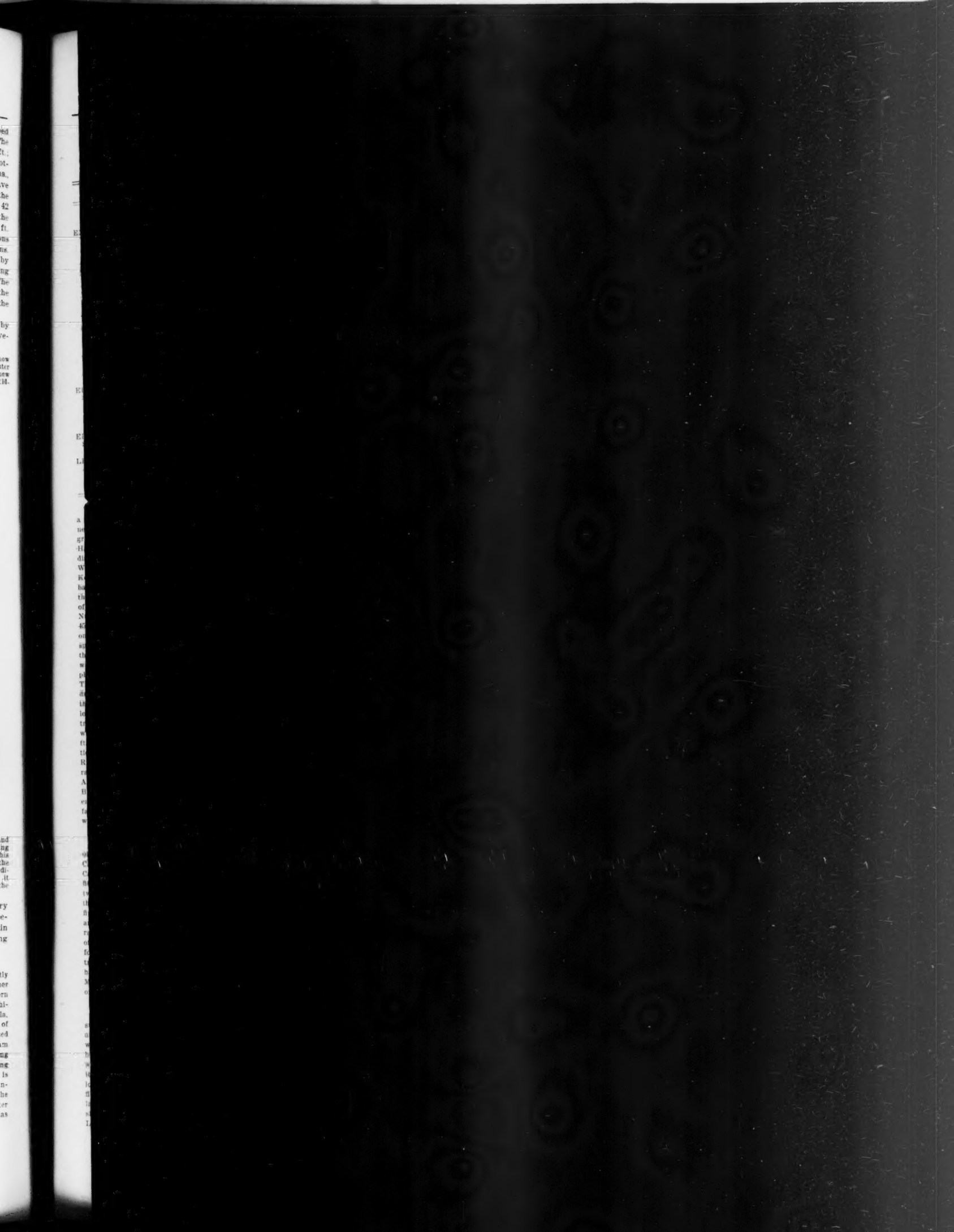
30-TON FOLDING GANTRY CRANE FOR THE CHESAPEAKE & OHIO RY. WHARVES, NEWPORT NEWS, VA.

We illustrate in the accompanying cuts a large capacity gantry crane of peculiar construction which has recently been erected at the wharves of the Chesapeake & Ohio Ry. at Newport News, Va., where it will be used largely for loading locomotives and other heavy articles from the railway tracks underneath to ships lying alongside. Fig. 1 shows the crane with the trolley at the center end and carrying a locomotive tender suspended by a sling. Fig. 2 shows it with the trolley just raising the load from the tracks underneath and with the outer leaf or boom folded up to clear the masts and funnels of vessels.

The construction of the crane is shown clearly by the photographs, and need not be described further. Its main dimensions are as follows: The spread of the crane legs at the bottom is 40 ft.; the height from the tops of the tracks to the bottom of the trolley track girders is 44 ft. 10½ ins., and the total height to the center of the sheave at the top of the forward leg is 78 ft. 4 ins.; the distance between the forward and rear legs is 42 ft.; the length of the folding leaf is 51 ft. and the total length of the trolley track girders is 105 ft. 3 ins. The main trolley has a capacity of 30 tons and the auxiliary trolley a capacity of 10 tons. The trollies and the folding leaf are operated by electric power, all the motor mechanism being housed in to protect it from the weather. The remaining details of the construction and the method of operation are clearly indicated by the illustrations.

This gantry crane was designed and built by the Wellman-Seaver Engineering Co., of Cleveland, O., who write us as follows:

You may be interested in knowing that we are now constructing a crane of the same type of much greater capacity for the Fore River Ship & Engine Co.'s new shipyards at Quincy, Mass. The crane that we are building for them will be equipped with a 50-ton trolley and an auxiliary trolley of 25 tons capacity and a masting tackle at the end of the jib of 10 tons capacity. This crane will be used for fitting up ships lying alongside the wharf, and will possess great advantages over the ordinary shear legs which are used for this purpose, as it will entirely do away with the necessity of working the ship for and aft inside the wharf.

We may remark in conclusion that the gantry type of crane, or walking crane, as it is sometimes called, is one that has been too little used in the United States. Abroad its merits have long been appreciated.

ACID IN MONONGAHELA RIVER WATER has greatly increased during the past few years, according to a paper recently read before the Engineers' Society of Western Pennsylvania by Mr. J. A. Mohr. Tests of the Youghiogheny River, a principal tributary of the Monongahela, in the summer of 1900 showed as high as 160 parts of acid per million. The increase is ascribed to the increased amount of coal-mine drainage discharged into the stream and also to the discharge of spent acid from the pickling vats of wire, tin-plate and other mills. Water containing acid rapidly corrodes boilers and when the percentage is above 60 to 80 parts per million, water-tube boilers cannot be used on account of the rapid perforation of the tubes. The acid can be counteracted by treating the water with an alkali, of which soda ash is the cheapest and as effective as any.